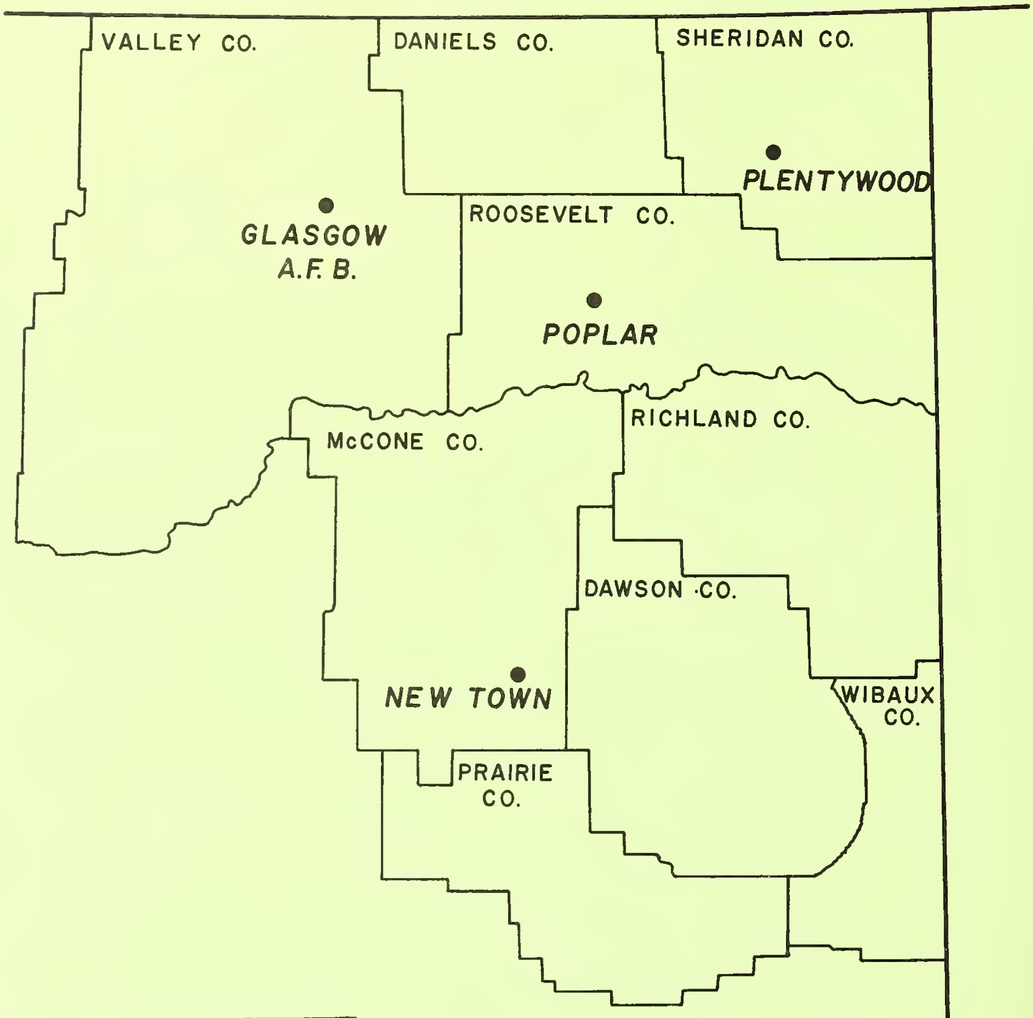
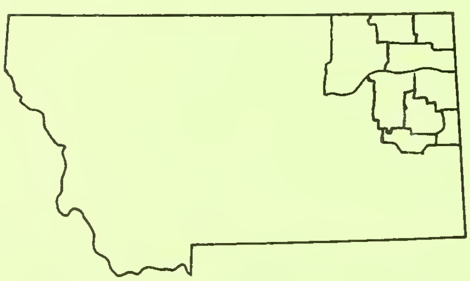
COAL GASIFICATION

Volume II

MONTANA ENERGY and MHD RESEARCH and DEVELOPMENT INSTITUTE, INC., Butte, Montana





POTENTIAL COAL GASIFICATION SITES IN NORTHEASTERN MONTANA

RESOURCE, ECONOMICS, AND SOCIAL ASPECTS OF A POTENTIAL COAL GASIFICATION PLANT IN NORTHEASTERN MONTANA

FINAL REPORT

prepared for

STATE OF MONTANA AND U.S. FEDERAL ENERGY ADMINISTRATION
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prepared by

MONTANA ENERGY AND MHD RESEARCH AND DEVELOPMENT INSTITUTE
and the
MONTANA TRADE COMMISSION
Butte, Montana

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STATEMENT

This report was prepared by professional consultants at the Montana Energy and MHD Research and Development Institute Incorporated under contract with the Office of the Governor, State of Montana, with funds provided by a state federal cooperation agreement with the U.S. Federal Energy Administration (FEA). Neither the Office of the Governor nor FEA has approved the report, nor do they guarantee the accuracy or the completeness of the data. The statements, findings, conclusions and recommendations contained in the report are solely those of the contractors and do not necessarily reflect the views of the Governor of Montana or FEA.

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I. EXECUTIVE SUMMARY

To develop a recommendation concerning the best location of a proposed Montana coal gasification facility, the Governor's Task Force requested assistance from the Federal Energy Administration and the state of Montana to examine particular factors associated with locating a coal conversion plant at Glasgow AFB versus other northeastern Montana mine-mouth locations. The Montana Energy and MHD Research and Development Institute is working under contract with these agencies to carry out this study. The overall objective of this study is to provide a basic input to the Montana Task Force on Coal Gasification toward their energy development strategy. Such strategy must incorporate a means to achieve the least adverse impact precipitated by the full range of development associated with coal gasification. These impacts include the extraction and transmission of coal, water, and coal conversion products as well as activities directly associated with the construction and operation of a gasification plant located at various potential sites.

Coal reserves sufficient to supply a 250 mm scfd[2] "Hygas" coal gasification plant at a rate of 9.8 mm tons/year exist within a 100-mile radius of most northeastern Montana potential plant sites. Estimates of existing reserves apparently are low due to the use of outdated reports on past coal-mapping efforts. Therefore, we recommended that the northeastern Montana region be mapped more adequately

to determine the coal reserves of the region in a more precise manner.

Seventy million tons of high-sulfur coal exist in the McKay seam located in Rosebud County (southeastern Montana). Unusable for conventional fossil-fueled power plants without extensive exhaust gas clean up systems, this resource would be highly suitable for use in coal gasification.

Unitization has been used in oil and gas operations for some time. Such a program in coal field operations would have the advantages of reduced operating costs, optimum coal recovery, coordinated land reclamation, and provision for more orderly royalty payments during the life of the coal field. Disadvantages of the concept include loss of individual rights, cost of forming a unit, and difficulties in determining the amount of resource per unit participant. At the present time, there is no enabling legislation allowing coal field unitization (as there is with oil and gas field unitization).

Slurry pipelines tend to be more sensitive to parameters such as volume shipped and distances traveled than unit train transportation. As these parameters increase, costs per ton decrease in an inverse fashion. Therefore, if a remote site is selected for the gasification facility, coal-feed requirements will tend to indicate which transportation mode is most effective. If through-put requirements are determined to be above the eight million ton per year level, slurry pipeline transport could be the preferred mode. However, if coal requirements tend to be below this level and the coal acquisi-

tion site is adjacent to existing rail services, unit train transportation would be desirable. A slurry system presently is not viable because of constitutional restrictions.

"Hygas" gasification plants of sizes 250, 180, and 83 mm scfd would use approximately 15,000, 11,500, and 5,300 acre feet of water per year, respectively, if evaporative-cooling towers are utilized. If dry cooling towers are substituted, water requirements would be substantially less, but operating efficiencey would be lower and costs higher.

The only certain source of water sufficent for coal gasification plants in northeastern Montana is the Missouri River and/or the Fort Peck Reservoir. A more important (and less defined) parameter than the physical availability or transportation costs of industrial water is the question of legal availability.

Construction of a water pipeline across the C.M. Russell Game Range which surrounds the Fort Peck Reservoir may not be politically or economically acceptable.

Capital cost estimates for installation of potential water pipelines in Montana range from a high of $4,069,000 per mile to a low figure of $652,000 per mile. Without the determination of specific routes, accurate costing cannot be done at this time. In general, the shorter the pumping distance, the lower the water transportation costs. Thus, cost preference would be towards Poplar, Glasgow Air Force Base, New Town, and Plentywood, respectively.

The output of a 250 mm scfd facility would surpass the capabilities of Montana Power Company's present gas distri-

bution system. This would necessitate utilizing the Montana-Dakota system or the development of an interstate pipeline for gas sales. A pipeline junction location with the Montana Power system has been determined southwest of Conrad, Montana.

Glasgow Air Force Base is the preferable location in terms of projected, direct gas transmission cost of the three potential sites considered.

On the basis of providing the most positive socioeconomic impact, analysis indicates that utilization of Glasgow Air Force Base would minimize potential social dislocation and would reduce capital requirements for infrastructural development.

To best determine which potential site is optimum (based on the above resource, economic, and social information), a matrix analysis was completed utilizing the MERDI Resource Constraint Maps of Montana. Table I-A shows the considerations most critical to siting a gasification plant in northeastern Montana. It also ranks the ability of each potential site to meet these conditions. This analysis shows conclusively that Glasgow Air Force Base is the superior site.

The strengths of the Glasgow AFB site lie in its ability to provide the necessary community services and potential labor force needed for a development of this magnitude. In addition, the local public previously has been exposed to periods of extremely high and low development activity, and they have demonstrated an ability to rebound from periods of low employment.

The community has further demonstrated ready acceptance for use of the air force base. Glasgow is not in near vicinity to wildlife refuges, nor does this site adversely affect hunted species as do other sites. These positive aspects overshadow the negative points of being at greater distance from sources of both coal and water.

COMPARISON OF ENERGY FACILITY SITING REQUIREMENTS WITH CHARACTERISTICS OF FOUR POTENTIAL SITES IN NORTHEASTERN MONTANA

			Sites			
Item	Siting Factor	Coal Gasification	GAFB	Poplar	Newtown	Plentywood
ENVIRONMENTAL CONSIDERATIONS		R*	S**	S	S	S
Land Use	Resource Use Preemption	L	0	-1	0	0
Hydrology	Water Availability	H	0	+3	-3	-3
	Flooding Potential	L	+1	-1	+1	+1
Ecology	Protected Areas/Species	H	0	0	0	-3
	Hunted Species	M	0	-2	0	-2
ECONOMIC FEASIBILITY CONSIDERATIONS						
	Resource Availability	H	-3	0	+3	+3
	Site Development Cost	H	+3	-3	-3	-3
	Cost of Transporting Product	L	+1	0	0	-1
SOCIOECONOMIC CONSIDERATIONS						
	Public Acceptance	H	+3	+2	-3	0
	Labor Force	H	+3	0	-3	0
	Stress on Community Services	M	+2	0	0	0
		TOTAL.	+10	-2	-8	-8

*R, Requirement Importance code: H--high; M--medium; L--low

**S, Suitability Weighting

TABLE I-A

II. BACKGROUND

The continuing energy crisis has had a relatively slight impact on the Montana region. However, it is becoming increasingly evident that energy shortages in the near future will produce substantial economic, employment, and environmental hardships for Montana.

A. Canadian Natural Gas Imports

In 1974, Montana's natural gas demand was approximately 85 billion cubic feet (BCF) per year. Of this total, approximately 66 percent or 55 BCF per year was imported from Canada. Montana Power Company, one of two utilities serving the state, provides natural gas to the western two-thirds of the state. This region contains two-thirds of the state's natural gas customers. Currently, this utility imports approximately 85 percent of its supply from Canada.

Effective May 4, 1975, the Canadian National Energy Board did not renew a Montana Power Company export lease which provided 10 BCF per year. Additionally, Canadians are seeking energy price parity with the imported Mideast oil resources. Consequently, the price of Canadian natural gas has escalated from $.23/MCF to $1.60/MCF in the past two to three years.

On May 11, 1976, the National Energy Board of Canada apparently denied Montana Power Company's request to import 39.2 BCF of natural gas per year through 1985. Instead, the board granted MPC the right to import only 34.2 BCF for one (1) year ending May 13, 1977. At that

date, the annual import rate would be cut another 5 BCF and possibly held at that level through 1985. As with the initial natural gas import cut of 10 BCF effective May 14, 1975, the 5 BCF cuts on May 11, 1976, and May 13, 1977, will have a critical effect on the energy supplies available to the company's interruptible industrial customers, reducing their 1977 supplies to 20 percent of that available before May 1975.

B. Montana Supplies

The balance of Montana's natural gas supplies are provided by in-state resources blended with a small portion of out-of-state resources. The recently expanded exploration program has been successful in providing a supply adequate for normal Montana residential requirements.

C. Montana Task Force on Coal Gasification

In June 1975, Governor Thomas Judge announced plans to pursue the possibility of a coal gasification plant and appointed a task force of private and public representatives to investigate and make recommendations in the following six areas: technology, environment, site, financial requirements, legal aspects, and citizen's involvement. The task force is charged with responsibility for bringing the feasibility of coal gasification and all related issues to a decisionable form and providing the Montana Congressional Delegation, the state of Montana, and the Governor with recommendations concerning each of the six topics listed above.

D. Glasgow Air Force Base Energy Center Study

In late 1974, the Federal Energy Administration (FEA) contracted with The Montana Energy and MHD Research and Development Institute, Inc. (MERDI), a private, nonprofit research organization, for a preliminary suitability study of establishing an energy center at Glasgow Air Force Base, located near Glasgow, Montana. The FEA's purpose for making the Glasgow study was to establish the principal issues and criteria involved in locating a number of energy producing and consuming facilities at a single site.

Glasgow Air Force Base is a 5,815-acre, potentially surplus federal property located in northeastern Montana. Most of the land surrounding the base is owned by the state of Montana, and if a suitable use can be found for Glasgow AFB, its ownership could be transferred to the state. It is a policy of the Federal government to encourage the use of surplus federal property for energy resource development.

Sufficient water is available in the Missouri River at the Fort Peck Dam, after serving all other present or planned uses, to supply an energy center of at least 10,000 MWe rating. Even 20,000 MWe of power production would utilize less than 5 percent of the mean annual flow of the river. Proximity of the Fort Union coal region, considered one of the largest coal regions in the world, to the Glasgow AFB (extensive deposits within 80 miles) assures an adequate and economical supply of a basic energy source to a Glasgow energy center.

In the first analysis, MERDI's findings and conclusions indicated generally that Glasgow AFB has substantial suitability for development into an energy conversion facility complex. Environmental impact of energy conversion facilities at Glasgow AFB would be the major limiting factor to the scope and extent of an energy center.

E. Mine Mouth Locations

Additional northeastern Montana mine-mouth locations such as New Town (to be located in McCone County), Plentywood, and Popular were chosen for objective comparison to the Glasgow Air Force Base site. The comparison includes determining the cost of transporting resources and products and the costs of constructing and operating a town complete with infrastructure and financial requirements.

III. GENERAL PLANT SITE CONSIDERATIONS

To determine the physical requirements of a coal gasification site, the "Hygas" gasification process was selected for study because of its lower dollar cost for synthetic natural gas (SNG) output and high thermal efficiency.[1] The actual SNG production output levels considered were 1) a high speculative level (250 mm scfd), 2) a mid level (180 mm scfd), and 3) the actual required size of an initial Montana SNG plant (83 mm scfd).

Four hypothetical plant sites in northeastern Montana were chosen for evaluation based on the estimated coal, water, infrastructure, and transportation requirements for plants of the above sizes. Specific northeast Montana locations (Glasgow Air Force Base, New Town-McCone County, Plentywood, and Poplar) were chosen as meeting one or more of the above requirements (see Figure 1). Because of time and data constraints, the Plentywood location was not included in the analysis of infrastructure and product distribution considerations.

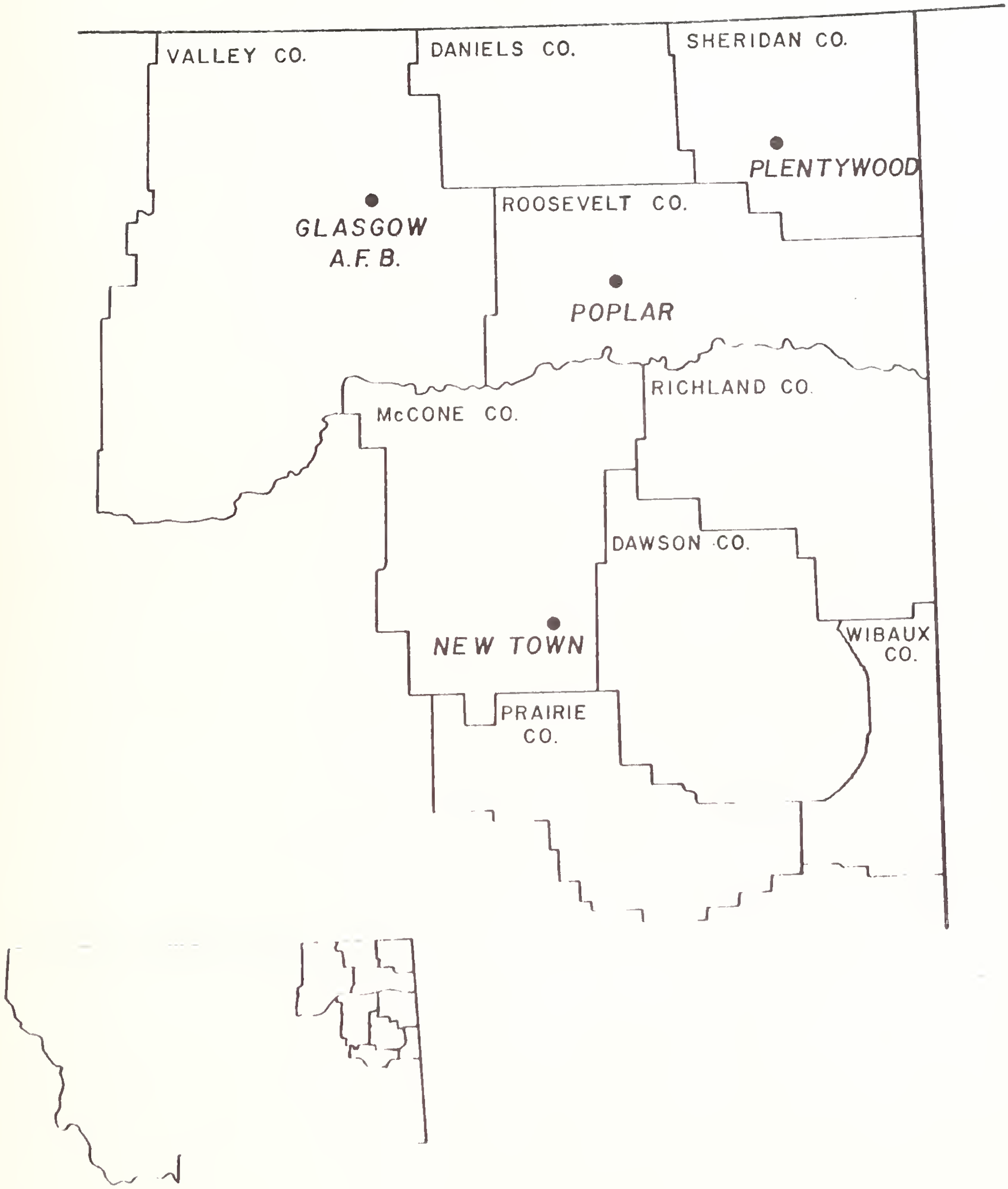


Figure 1. Northeastern Montana Potential Sites

IV. COAL RESOURCES

The eastern part of Montana provides a vast area of coal reserves. The location and extent of these reserves in comparison to the requirements of a coal gasification plant will influence the decision on such a plant's location.

In addition, questions concerning the utilization of high sulfur coal, the application of unitization to coal supplies, and the affect of varied methods of coal transport will be of significant importance to coal gasification development.

A. Coal Field Location and Reserves[3]

The area covered by this report includes the counties of Sheridan, Daniels, Roosevelt, Richland, Dawson, and McCone. These counties lie in the northeastern part of Montana.

The land use of northeastern Montana is comprised of dry land grazing and irrigated farming and ranching activities. Ownership in the area is limited mostly to private individuals who purchased the land from the government, which still retains many mineral rights. Some of the land is owned by the Burlington Northern Railroad and the Fort Peck Indians (whose reservation covers portions of Valley, Roosevelt, Daniels, and Sheridan Counties).

The majority of the information compiled on the coal fields located within these counties comes from U.S. Geological Survey bulletins[4] issued during the first four decades of this century.

Figure 2 was compiled by the Montana Bureau of Mines and Geology from the USGS reports just noted as well as other studies performed by the MBMG.[5] Table I-B describes the strippable coal depicted in Figure 2. Values for the estimated reserves in millions of tons and the acreage of the area were established from the USGS reports and other preliminary work.[4]

One of the major problems with older reports is their lack of detailed information. In many cases, the thickness and extent of the coal beds were inferred only from outcroppings of the coal beds themselves. Wherever underground mines were located, the investigators could measure coal bed thickness inside the mine. Modern methods of drilling and well logging were unheard of during the early investigations. Only in the last few decades have these methods been employed in mapping coal fields.

Figure 3 shows a map of eastern Montana and the areas which are underlain by coal-bearing rock formation. Nearly all the coal in northeastern Montana is lignite, the lowest grade of coal. These coal reserve estimates are almost certainly conservative in nature since the fields could not be explored adequately with early mapping techniques. Also, the estimates were of the total available coal, 50 percent of which is recoverable through various mining techniques. The following sections describe the coal fields in detail.

TABLE 1 Strippable subbituminous and lignite coal fields, eastern Montana

No. on map	Name of field	Coal bed	Est. reserves in millions of tons	Acreage	Average tons/acre	Ash[1]	Sulfur[1]	Btu[1]
1	Decker	Anderson-Dietz 1&2	2,239.99	25,523	87,763	4.0	.40	9,652
2	Deer Creek	Anderson-Dietz 1&2	495.65	14,214	35,397	4.0	.50	9,282
3	Roland	Roland	218.04	12,076	18,055	9.2	.74	8,164
4	Squirrel	Roland	133.41	6,208	21,490	5.5	.29	7,723
5	Kirby	Anderson	216.52	5,655	38,285	4.2	.32	8,328
		Wall	473.69	5,952	70,579			
		Dietz	834.35	17,516	47,630	5.8	.59	8,509
		Canyon	158.53	4,066	38,983	5.8	.24	8,789
6	Canyon	Wall	1,884.25	23,859	78,974	4.6	.30	9,088
		Brewster-Arnold	65.86	2,067	31,859	7.5	.40	8,444
7	Birney	Brewster-Arnold	180.55	6,969	25,905	5.1	.41	9,055
8	Poker Jim Lookout	Anderson-Dietz	872.65	19,609	44,501	5.2	.37	7,925
9	Hanging Woman Cr.	Anderson	1,583.29	30,547	51,830	4.9	.29	8,496
		Dietz	1,120.96	43,654	25,678	5.5	.33	8,078
10	West Moorhead	Anderson	883.74	19,660	44,949	5.3	.36	8,296
		Dietz	397.49	29,416	19,469	4.1	.41	7,990
		Canyon	690.19	22,547	30,611	5.6	.45	8.055
11	Poker Jim O'Dell	Knobloch	373.29	7,890	47,311	5.1	.22	8,846
		Knobloch	564.78	7,187	78,581			
12	Otter Creek	Knobloch	2,075.55	25,791	80,475	4.7	.36	8,468
13	Ashland	Knobloch	2,696.20	27,200	99,125	4.8	.15	8,421
		Sawyer A&C	357.49	20,262	17,643	4.9	.49	7,883
14	Colstrip	Rosebud	1,439.26	33,379	43,118	9.5	.12	8,836
15	Pumpkin Creek	Sawyer	2,426.50	45,695	53,102	7.5	.34	7,438
16	Foster Creek	Knobloch	708.15	27,801	25,470	7.8	.76	7,573
		Terret	460.87	27,462	16,782	5.8	.21	7,770
		Flowers-Goodale	258.90	14,444	17,924	7.8	.51	7,553
17	Broadus	Broadus	739.82	18,429	40,142	7.2	.27	7,437
18	East Moorhead	T	525.21	15,559	33,756	6.2	.57	7,120
19	Diamond Butte	Canyon	418.02	21,363	19,566	4.8	.43	7,330
20	Goodspeed Butte	Cook	628.95	13,446	46,775	10.6	1.63	6,771
21	Fire Gulch	Pawnee & Cook	336.69	8,486	39,674	3.8	.33	7,739
22	Sweeney-Snyder	Terret	326.33	10,921	29,880	9.1	.11	8,175
23	Yeger Butte	Elk & Dunning	1,175.86	26,924	43,673	4.8	.33	7,646
		Cook	312.02	14,507	21,507	6.7	.63	7,254
24	Threemile Buttes	Canyon & Ferry	225.40	13,836	16,289	5.5	.94	6,867
25	Sonnette	Pawnee	320.25	8,224	38,940	9.8	.88	6,964
		Cook	362.98	10,470	34,668	8.1	1.23	6,891
26	Home Creek Butte	Canyon & Ferry	217.21	4,851	44,774			
27	Little Pumpkin Creek	Sawyer A&C,D,X,&E	215.83	8,534	25,290			
28	Sand Creek	Knobloch	267.34	5,952	44,915	6.6	.30	7,340
29	Beaver-Liscom	Flowers-Goodale&Terret	135.87	8,851	15,350	8.1	.96	8,102
		Knobloch	491.62	17,075	28,791	7.7	.50	8,027
30	Greenleaf-Miller Creek	Rosebud, Knoblock & Sawyer	453.71	14,918	30,413	7.5	.71	8,422
31	Pine Hills	Dominy	193.87	6,022	32,191	7.2	.53	7,293
32	Knowlton	Dominy (M&L)	747.51	19,613	38,112	7.1	.41	6,710
		Dominy (U)	120.31	4,448	27,048	5.6	.38	6,645
33	Sarpy Creek	Rosebud-McKay	1,500.00	42,373	35,400	6.5	.50	8,600
34	Cheyenne Meadows	Knobloch	1,200.00	13,560	88,500	4.1	.40	8,400
35	Little Wolf	Rosebud-McKay	314.00	7,411	42,370			
36	Jeans Fork		90.00	3,800	23,685			
37	Wolf Mountains		1,922.00	31,000	62,000			
38	Lame Jones	Domeny	150.00	10,593	14,160			6,020
39	Lamesteer	Harmon(?)	35.00	1,978	17,700			6,332
40	Wibaux	C	643.00	18,518	34,720	7.9	.90	6,050
41	Little Beaver	C	134.00	8,445	15,865			

TABLE I-B

42	Four Buttes	C	91.00	5,180	17,570			6,140
43	Hodges		10.00	807	12,390			
44	Griffith Creek		10.00	568	17,700			
45	Smith-Dry Creek	G	150.00	8,475	17,700			
46	O'Brian-Alkalie Creek		150.00	8,475	17,700			
47	Breezy Flat	Pust	200.00	7,062	30,090	6.7	.50	6,660
48	Burns Creek	Pust	4,400	133,951	30,090			
49	N.F. Thirteen Mile Creek	Pust	4,400	133,951	44,250			6,880
50	Fox Lake	Pust	46.00	2,166	21,240			6,880
51	Lane	Lane	561.00	44,582	12,390			7,150
52	Carroll	Carroll	345.00	29,780	11,584	5.5	.30	7,400
53	Redwater River	S	642.00	24,181	26,550	6.1	.40	7,400
54	Weldon-Timber Creek	S	724.00	25,565	28,320			7,660
55	Fort Kipp	Ft. Kipp-Ft. Peck	331.00	14,500	22,830	4.6	.20	6,110
56	Lanark	Lanark	100.00	3,531	12,390	6.3	.40	6,853
57	Medicine Lake		58.00	3,740	15,510	7.2	1.00	6,870
58	Reserve		246.00	18,211	11,495	7.6	.40	6,599
59	Coal Ridge	Coal Ridge	150.00	19,200	17,700	7.5	.40	5,810
60	Carpenter Creek	Carpenter	50.00	1,211	14,015	6.5	.40	9,270
61	Charter	Mammoth	60.00	1,210	17,700	6.0	.90	10,190
62	Little Sheep Mtn.	A&C	200.00	10,272	19,470			
		TOTAL	42,561.91	1,152,640				

1"As received" basis (where more than one sample available, figures given are average figures).

By Robert E. Matson

TABLE I-B
(Cont.)

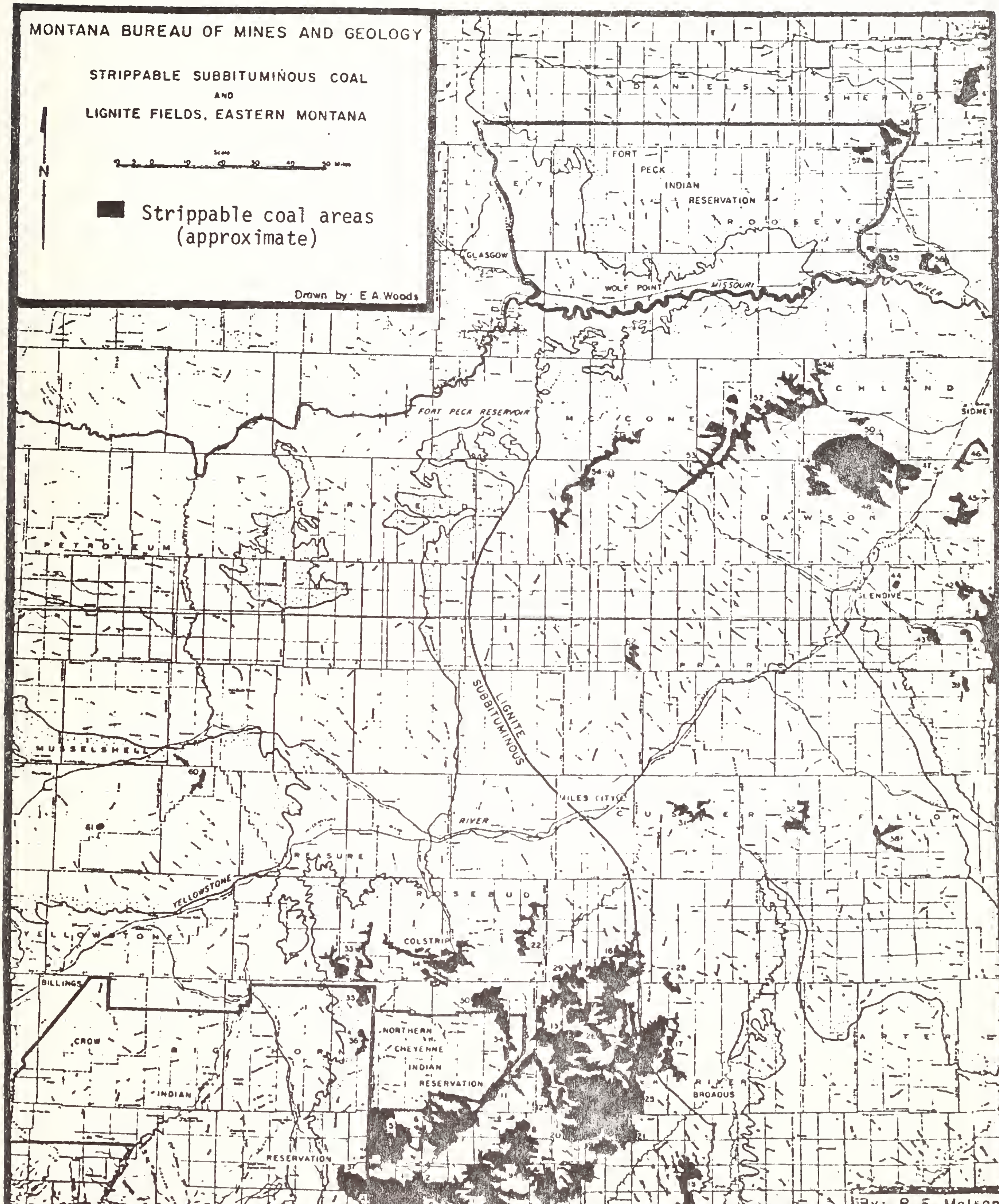


Figure 2. Map showing the strippable coal deposits of northeastern Montana.

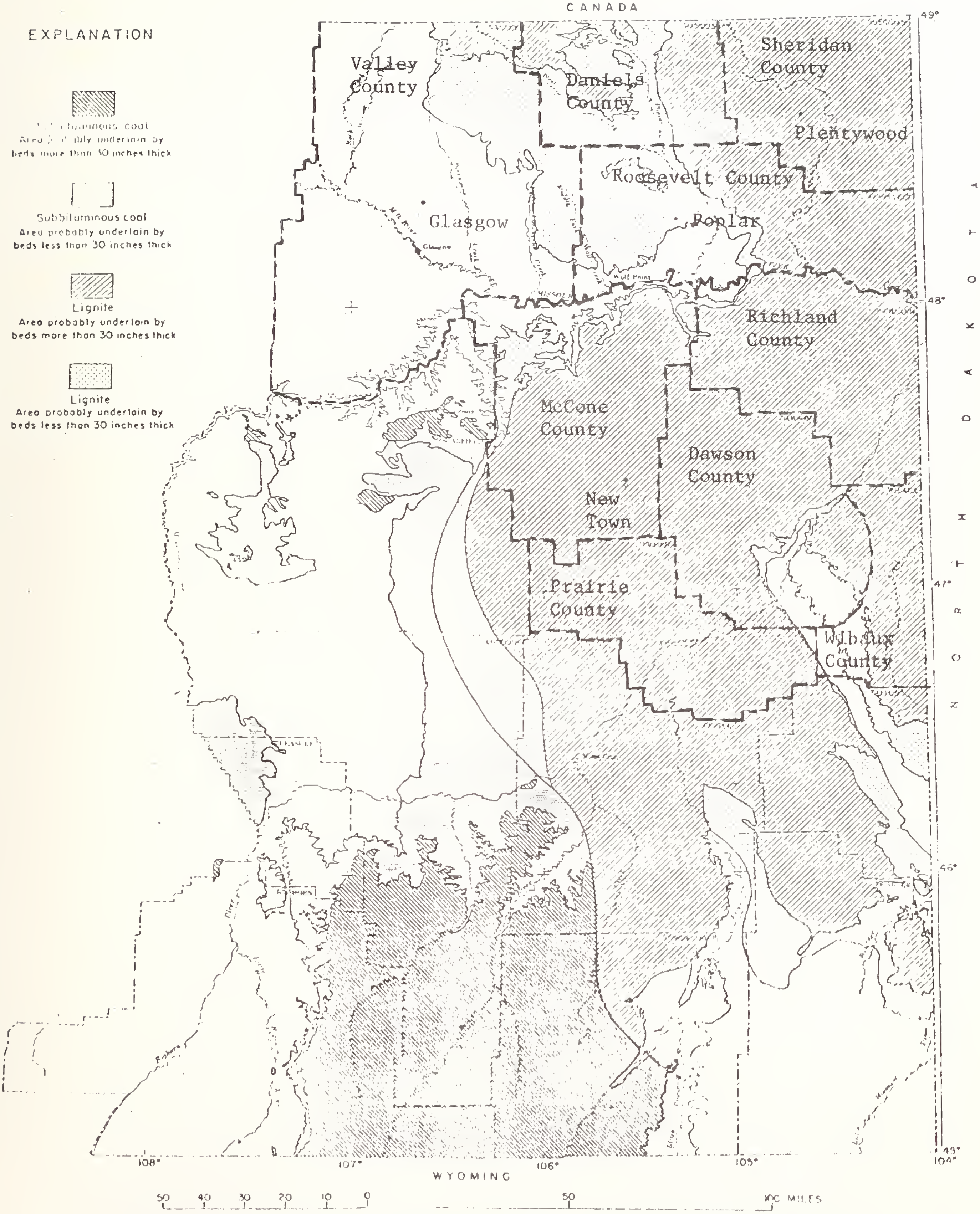


Figure 3. Map of eastern Montana showing areas underlain by coal-bearing rocks.

1. Glendive Lignite Field

The Glendive lignite field is located in Dawson County.[7] It is bounded to the north by T. 18 N and to the south by T. 12 N. It extends from R. 52 to the Montana-North Dakota border. The approximate location is shown in Figure 4. The Lance formation contains several thin, lenticular coal beds whereas, the Fort Union formation contains several beds, one of which is 4 feet thick and extends 150 miles. The average thickness of these beds is 4 to 8 feet, and they vary in quality.

Three or four methods were used to obtain the ash, sulfur, and heat production of the coal. For comparison, the chemical properties of the coal also were determined after the coal had been dried and a constant weight achieved. The properties listed in this report will be confined to those obtained as the coal was received from the field. Coal in the Glendive field contained 0,7-1.4% sulfur and 6.2-8.3% ash and produced 6690-7770 Btu. No exact information on the depth of the beds below the surface was given; however, it was indicated that some coal was found with less than 200 feet of overburden. Matson stated that an area 10 miles southwest of Glendive contains reserves of 770 million tons of strippable coal in an area of 29,500 acres with an overburden ratio of 1:10.[6]

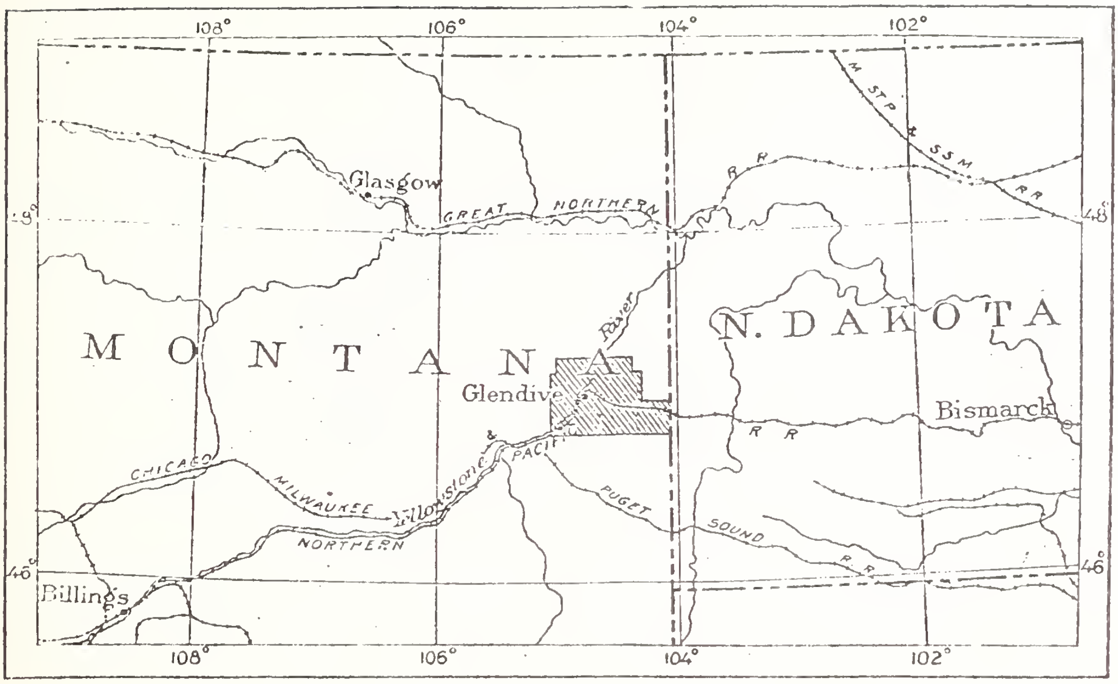


Figure 4. The Glendive lignite field.

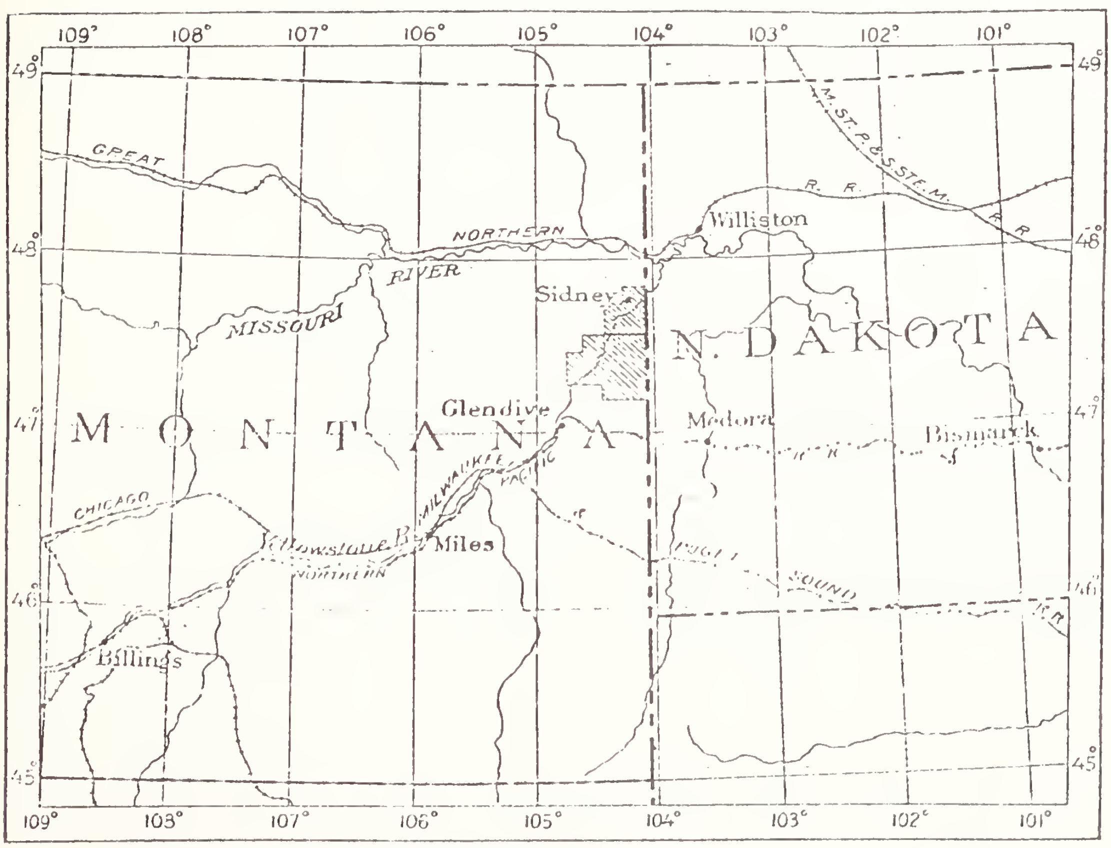


Figure 5. The Sidney lignite field.

The only mining activities were at the Snyder Mine, a commercial prospect, and a few other smaller mines supplying local needs. The output of the Snyder Mine was about 25 tons per day.

2. Sidney Lignite Field

The Sidney lignite field is located in Richland and Dawson Counties.[8] It extends from R. 56 E to the Montana-North Dakota border and from T. 17 N to T. 23 N. The approximate location is shown in Figure 5. Most of the coal is located within the lower member of the Fort Union formation.

Coal beds up to 120 miles long were reported. In the western part of the field, the ratio of coal to coal-bearing rock is 1:20 (49 feet of coal), but in the eastern section, the ratio is 1:40. The amount of overburden covering the field varies from 75 to 200 feet. Thus, there probably are some areas conducive to strip mining. However, the strippable beds are only about 4 feet thick with at least 50 feet of separation between them. The thickest bed (9 feet) is too far beneath the surface to be strip mined since it is about 350 feet below the bed nearest the surface.

Chemical analysis revealed about 6.3% ash, 0.6% sulfur, and a heat production of 6880 Btu from the coal as received from the field.

It was estimated that the entire field contains 23 billion tons of coal; about 12.5 billion tons are

recoverable by mining. There were no mines in the area except for a few small open pits to supply local needs. Sahinen indicated that the amount of coal in Richland County was 7 billion tons, due primarily to the presence of the Sidney field.[9]

3. Culbertson Lignite Field

The Culbertson lignite field[10] in Sheridan and Roosevelt Counties extends from the Canadian border south to T. 27 N and from the Montana-North Dakota border west to R.54 E (see Figure 6). The coal is located within the Fort Union formation.

Beds range in thickness from 3 to 7 feet and extend from 30 to 40 miles in some locations. Glacial drift covers the entire district, making it difficult to ascertain the characteristics of the beds because of the lack of outcroppings. No information concerning the depth of the various beds beneath the surface was available.

Chemical analysis showed 4.1-9.1% ash, 0.2-1.3% sulfur, and a heat production of 5280-6710 Btu. The amount of coal estimated to be within 500 feet of the surface is 17 billion tons; about 9.3 billion tons are recoverable through mining. The total amount of coal in the field is estimated at 33 billion tons, with 18 billion tons recoverable. A few strip and drift mines were in operation to supply the needs of local people.

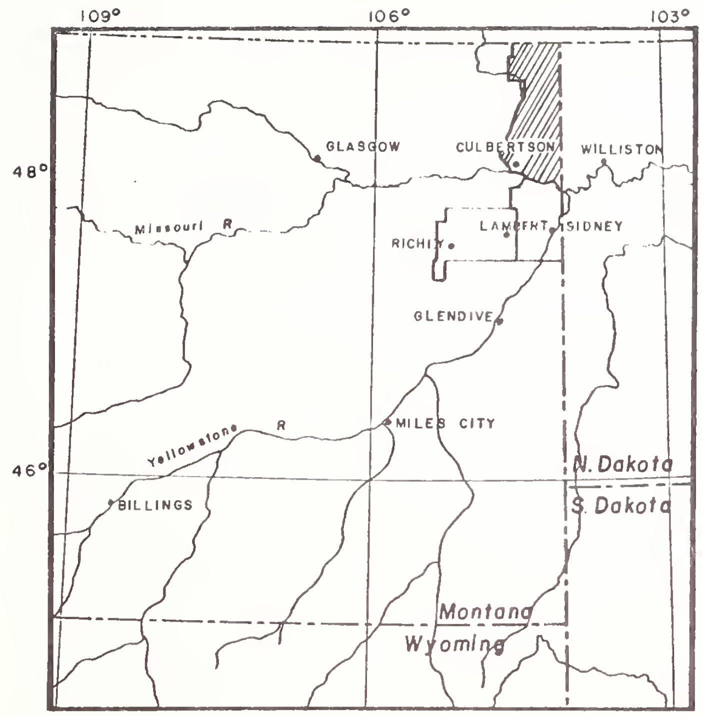


Figure 6. The Culbertson lignite field.

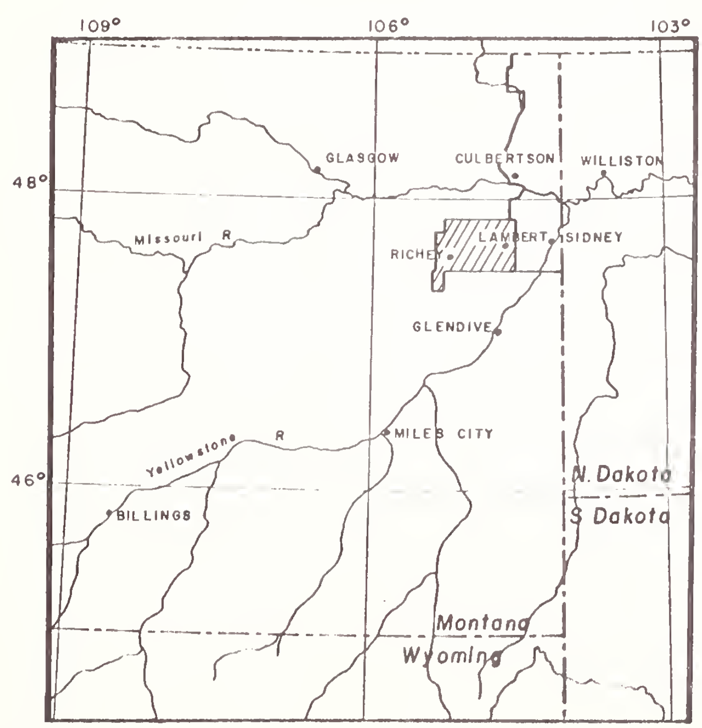


Figure 7. The Richey-Lambert coal field (no.33)

4. Richey-Lambert Coal Field

The Richey-Lambert coal field in Richland and Dawson Counties extends from about T. 21 N to T. 24 N and from R. 50 E to R. 55 E.[11] The area is depicted in Figure 7 as number 33. Numbers 11, 12, 13, 14, and 15 are the Culbertson, Scobey, Fort Peck, Sidney, and Glendive Fields, repectively. There are numerous coal beds located within the Lebo and Tongue River members of the Fort Union formation.

Maximum thickness of the beds ranges from 4 to 21 feet. The Pust bed has the greatest commercial value of all beds in the field, averaging 11 feet thick in the southern portion of the field. The Pust is overlain by the Prittegurl which is 6 feet thick (maximum). Beds at lower levels yield substantial amounts of coal but would not be good for strip mining because of the amount of overburden. The Pust bed has about 2.4 billion tons of coal. There are a few areas where the coal only has 50 feet of overburden and is 5 feet thick. Such areas may be strippable. In the area T. 24 N, R. 51-53 E, the height of the base of the Carroll bed is only about 100 feet beneath the surface, and it ranges in thickness from 2 to 9 feet. Sahinen indicated that the Richey-Lambert field contained about 5.5 billion tons of coal in Richland County.[9]

Chemical analysis showed 5.0-7.4% ash, 0.3-0.9% sulfur, and a heat production of 6710-9050 Btu. There were several small mines at that time supplying local needs.

5. Fort Peck Indian Reservation Lignite Field

The Fort Peck Indian Reservation Lignite Field[12] lies in Roosevelt, Valley, and Daniels Counties and extends from about R.41 E to R. 54 E and from T.25 N to T. 33 N (see Figure 7). The Fort Union member contains several beds varying in thickness from 2 to 10 feet. There is no information on the amount of overburden.

Chemical analysis showed 5.8% ash, 0.3% sulfur, and a heat production of 6000 Btu. There was only one underground mine and a few open pits to supply local needs.

6. Fort Kipp Field

The Fort Kipp field[13] is located in Roosevelt County and covers T.28-29 N and R. 53-55 E (see Figure 8). Two major coal beds which lie in the Fort Union formation are the Fort Peck and Fort Kipp seams.

The Fort Peck seam, which is 3 to 9 feet thick and averages 5.4 feet thick, overlies the Fort Kipp seam. This seam averages 8.5 feet thick and varies from 7 to 10 feet. Sediment between the two seams varies from 7 to 49 feet and averages 27 feet in thickness. In places, the Fort Peck seam lies within 11 feet of the surface and, therefore, would be ideal for strip mining.

Chemical analysis showed 4.1-14.0% ash, 0.2-2.4% sulfur, and a heat production of 5400-7143 Btu. There are 11,000 acres of lignite within 125 feet of

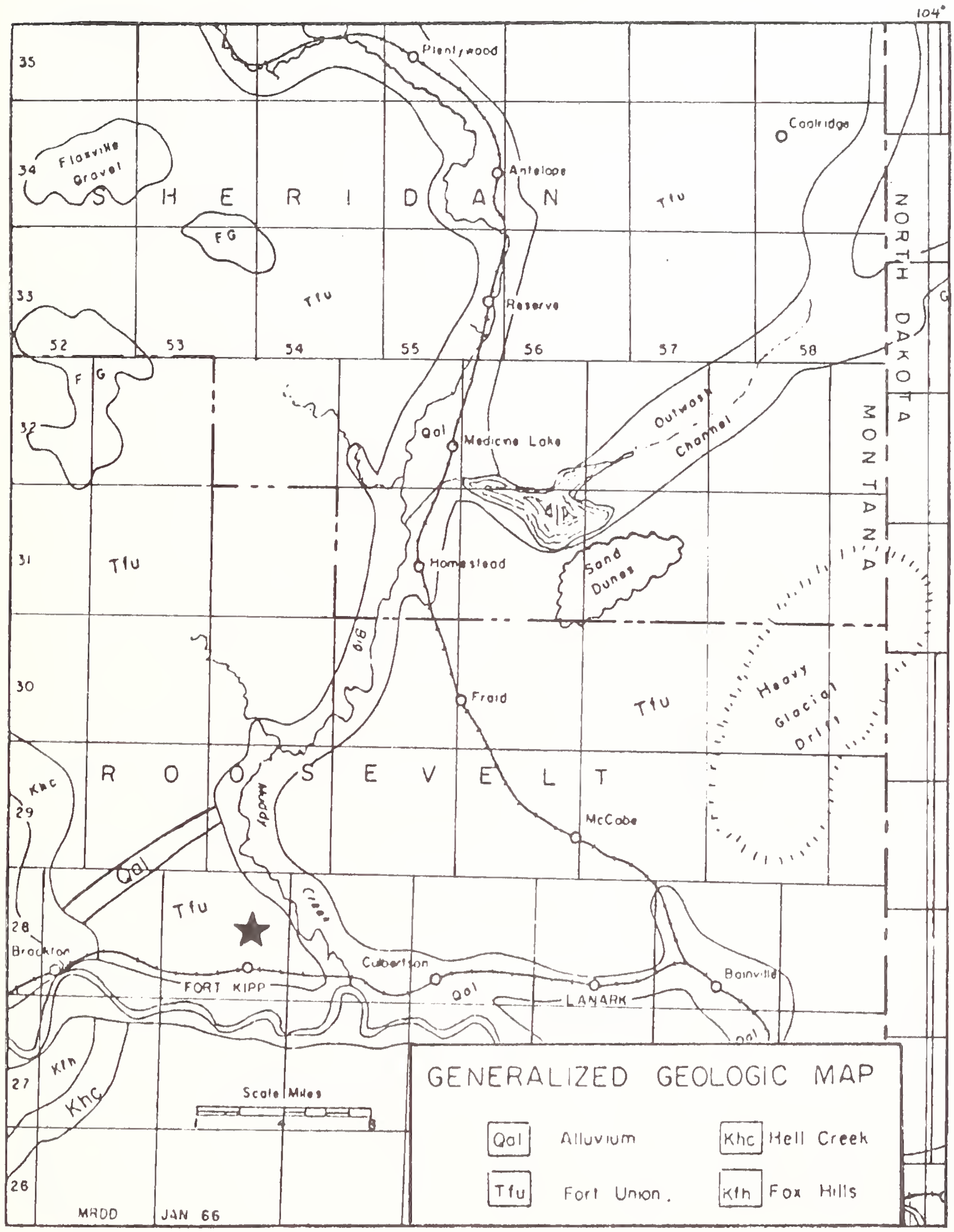


Figure 8. The Fort Kipp lignite field.

the surface. The total estimated reserves are 330 million tons; approximately 245 million tons are overlain by 125 feet or less of overburden. No information on mining activity was available.

7. Sentinel Butte Field

The Sentinel Butte field[14] is located in Dawson County and covers T. 14-16 N and R. 59-60 E. Figure 9 shows the approximate location. Coal beds lie within the Fort Union formation.

There are several thin (less than 3 feet thick) beds in the field. The maximum thickness is about 6 feet. No estimate of the amount of overburden overlying the beds was available.

Chemical analysis shows 5.6-8.9% ash, 0.8-1.5% sulfur, and a heat production of 5819-6806 Btu. It was estimated that there were 33 billion tons of coal within 100 feet of the surface. Mining was limited to local needs.

8. Scobey Lignite Field

The Scobey lignite field was explored by two investigators, Bauer[15] and Collier[16]. It occupies portions of Valley, Daniels, and Sheridan Counties and extends from R. 39 E to R. 55 E and T. 33 N to T. 37 N (see Figure 10). The coal beds are part of the Fort Union and Lance formations.

In the vicinity of Plentywood, there are beds 3 to 6 feet thick within 500 feet of the surface. Beds

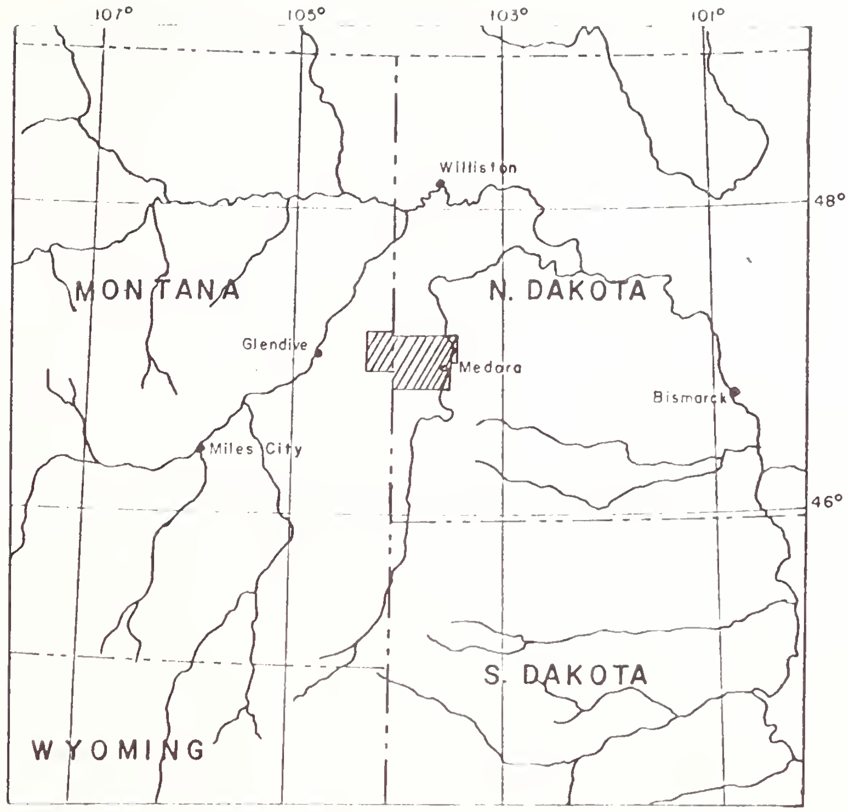


Figure 9. The Sentinel Butte lignite field.

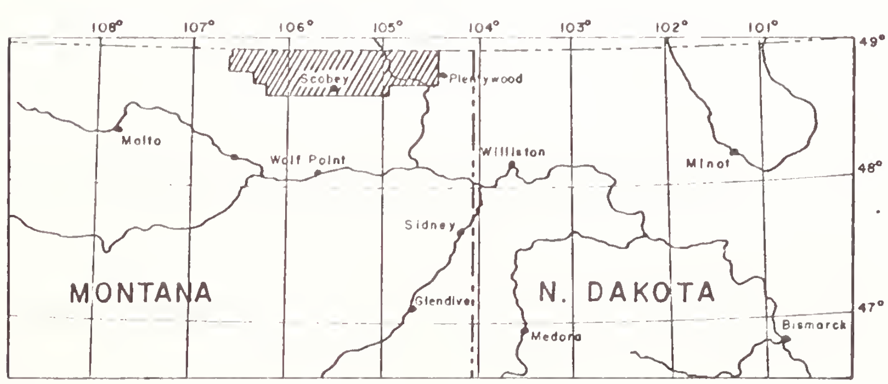


Figure 10. The Scobey lignite field, Montana.

in other portions of the field generally were thought to be less than 4 feet thick with an occasional bed 6 to 8 feet thick. It is apparent that beds in the far northeastern part of the state are thinner than those further south. The amount of reserves was estimated at 9 billion tons.

Chemical analysis figures differed somewhat between investigators but were within the extremes of 5.8-9.9% ash, 0.2-1.4% sulfur, and a heat production of 5470-7500 Btu. In the vicinities of Plentywood and Scobey, the coal had been stripped by local people to supply their needs.

9. Girard Field

The Girard field[17] is located in Richland County and extends from T.21 N to T. 27 N and R. 55 E to R. 59 E (see Figure 11). The coal is located within the Fort Union formation.

All the known coal in the field is less than 1000 feet below the surface. Thirteen percent of the coal in the field is 2.5 to 5.0 feet thick, 62 percent is 5 to 10 feet thick, and 25 percent is greater than 10 feet thick. Lack of information prohibits determining resources for stripping potential, but a considerable amount of coal in some areas is covered by less than 200 feet of overburden.

Chemical analysis showed an ash content of 6.7-7.5% and a sulfur content of 0.4-0.8% using coal as received from the field. Therefore, the coal is much lower in sulfur content than most coals in the areas.

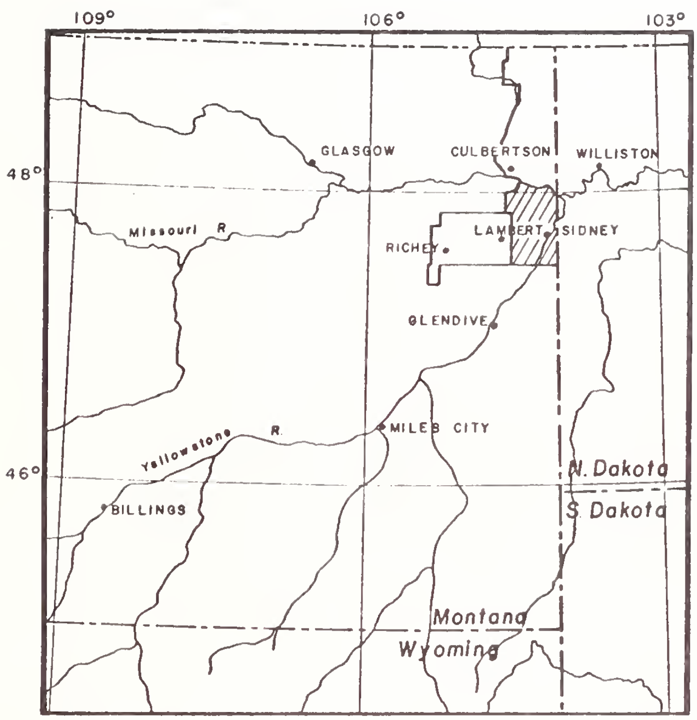


Figure 11. The Girard coal field, Montana.

The heat production ranges between 6270 and 7150 Btu. Twenty-eight townships in the coal field contain lignite. The field contains estimated resources of 5.1 billion tons; resources in beds 5 to 10 feet thick total about 400 million tons and total about 156 million tons in beds greater than 10 feet thick. Sahinen indicated that there were 3.4 billion tons in the northern part of the field and that the average reserves per township in Richland County were 420 million tons or 24 billion tons for the entire county.[9] His chemical analysis figures were 6.0-7.5% ash, 0.4-0.9% sulfur, and a heat production of 6270 to 7150 Btu.

For many years, the coal was mined for local needs only. During 1950 and 1951, mines produced 14,000 and 11,000 tons. The Jennison mine had a maximum production of 100 tons per day in 1951. The Crosby mine produced 2000 tons in 1950. There were several other mines with lower production rates, and the Sorenson strip mine produced 121 tons in 1950. Currently, the Knife River Coal Mining Company mines the Breezy Flat strippable deposit.

10. Yellowstone River Deposits

Culbertson reported on three small, strippable deposits west of the Yellowstone River.[18] Figure 12 shows the location and extent of these deposits. Nearly all the coal beds are in the Tongue River member of the Fort Union formation.

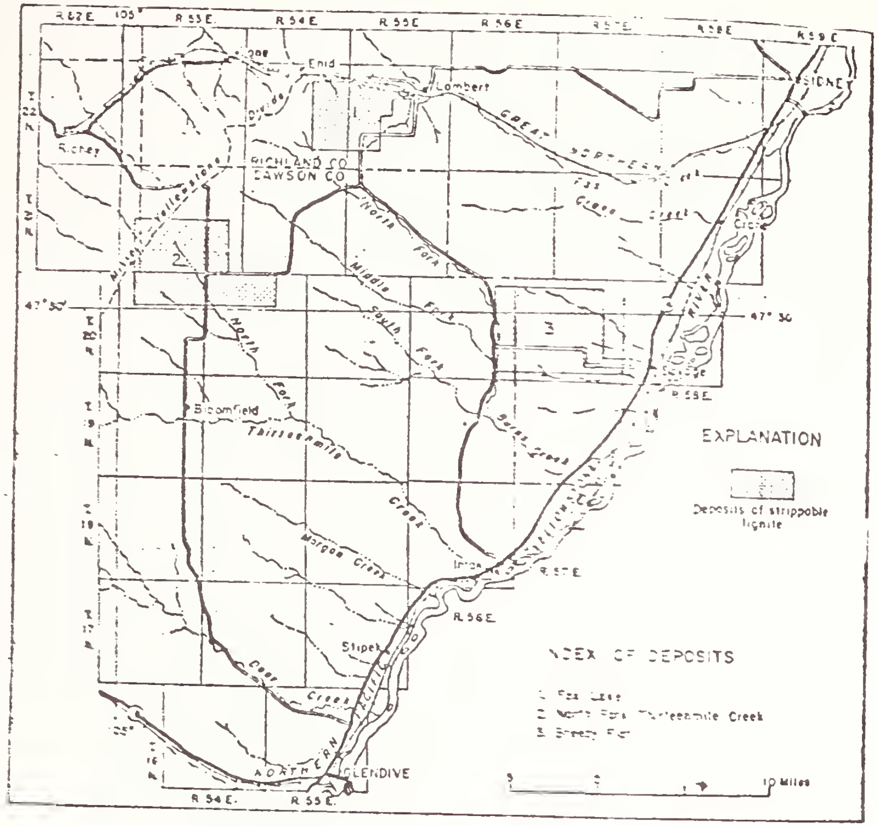


Figure 12. The three strippable lignite deposits west of the Yellowstone River.

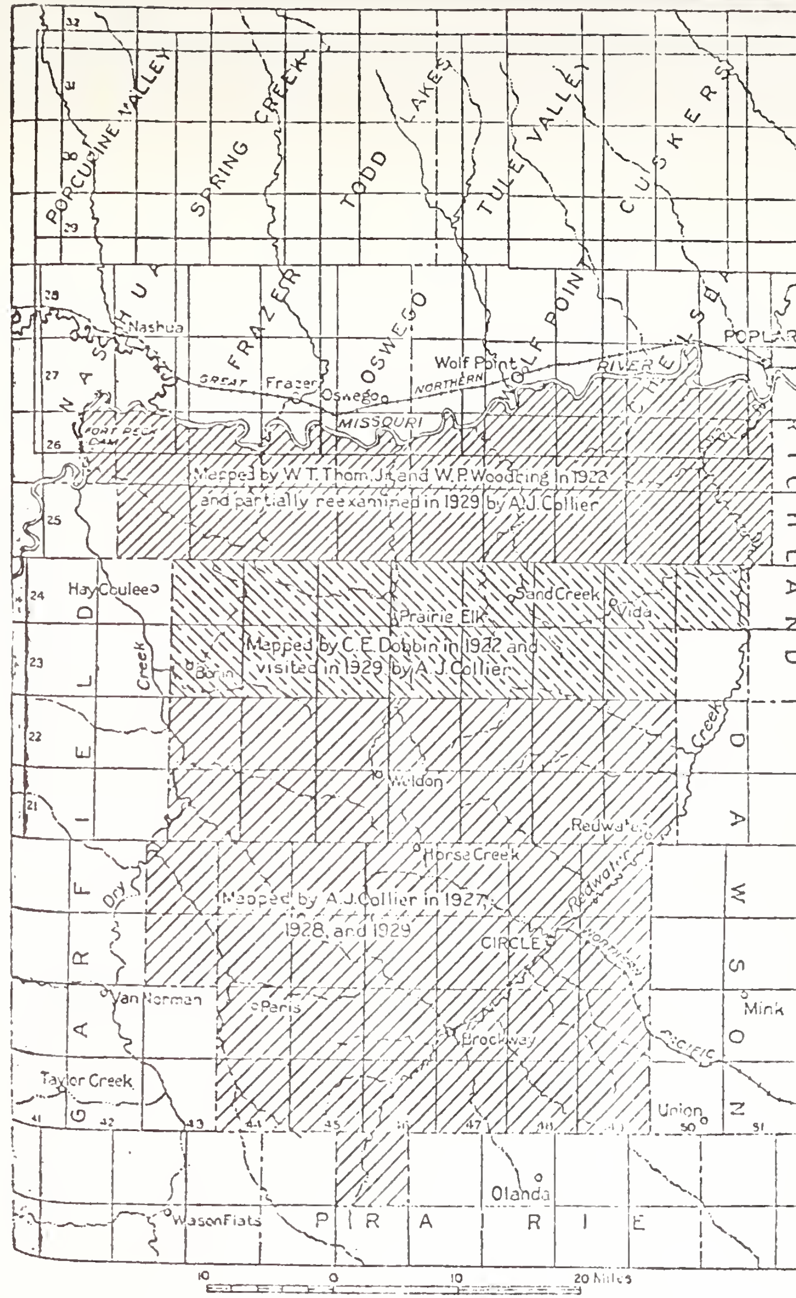


Figure 13. Map showing McCone County, Montana.

Culbertson's report commented on the depth of beds in the Glendive coal field just east of the Yellowstone River. One bed is 50 feet below the surface and is strippable. West of the river, the Pust bed is the thickest (up to 43 feet thick) and the most continuous bed of the three deposits. The Fox Lake deposit is two miles southwest of Lambert. The Pust bed at this location is about 7 to 17 feet thick, averaging 11 feet thick. The deposit contains 46 million tons under 120 feet of overburden in an area of 2400 acres. There are 36 million tons under 60 feet of overburden. The Breesy Flat deposit is 4 miles west of Savage. The Pust bed is 9 to 25 feet thick and averages 14 feet thick in that area. The reserves total about 200 million tons under 90 feet of overburden in an area of 8900 acres. The North Fork Thirteen Mile Creek deposit is 6 miles north of Bloomfield. The lignite is 10 to 43 feet thick, averaging 25 feet in thickness. The deposit contains 225 million tons under less than 120 feet overburden and 103 million tons under less than 60 feet of overburden in an area of 5200 acres. However, results of a survey conducted during the summer of 1976 indicate the reserve estimates were low for the North Fork Thirteen Mile Creek area. (Refer to Table I for the most recent values.) Total reserves of the three strippable lignite deposits were estimated at 491 million tons in 1954.

Chemical analysis showed 5.5-8.5% ash, 0.3-1.4% sulfur, and a heat production of 6530-7400 Btu. The Pust bed was strip mined by the Albrecht Mine at the North Fork Thirteen Mile Creek Deposit.

Culbertson states that beds 5 feet thick are the minimum thickness required for strip mining. Also, the maximum overburden should be about 120 feet for a relatively thick (20 feet) bed. If the bed is thinner, the amount of overburden should be less. Recovery of lignite in large strip mines is 80-90 percent of the coal originally in the ground.

11. McCone County

The coal resources of McCone County were investigated by Collier and Knechtel[19] and later by Matson.[20] The area under consideration is shown by the hatching in Figure 13. McCone County coal is contained in the Fort Union formation.

The Tullock member contains beds from 1 to 6 feet thick to a maximum of 9 feet thick. The lebo member contains the "Big Dirty" bed which varies in thickness up to 20 feet. The S bed (up to 20 feet thick) is of commercial value. Generally, its sulfur content is low. The P bed (the bed nearest the surface) is up to 9 feet thick and strippable.

Chemical analysis revealed 5.5-11.7% ash, 0.2-1.1% sulfur, and a heat production of 6610-8160 Btu. Collier and Knechtel estimated total reserves of 25 billion tons, and Matson estimated 17 billion tons of strippable

coal. He suggests that further evaluation of the field may yield another 5 billion tons of strippable coal. In 1939, mining was limited to a few underground and strip mines used to supply local needs.

All investigators agreed that the strippable deposits lie along Weldon-Timber Creek in townships T. 18 N, R. 44 E to T. 22 N, R. 46 E in the western part of the county and Redwater Creek northeast of Circle to township T. 20 N, R. 49 E. Matson states that the strippable part of Redwater Creek is confined to the low valley sides, and the bed ranges from 8 to 21 feet thick. It is estimated that there are 642 million tons of strippable coal lying under 150 feet of overburden. In the Weldon-Timber Creek area, the strippable area is one-half to two miles wide, and beds are up to 20 feet thick. The reserves are estimated at 724 million tons at Weldon-Timber Creek.

12. Fort Union Formation

Colton[21] describes the coal reserves contained in the Fort Union formation in the Otter Creek Quadrangle in the far northeastern part of Montana just south of Plentywood. Figure 14 depicts the area.

The Richardson coal bed is 2 to 8 feet thick, and the Timber Coulee bed is 8 to 9 feet thick. Colton states that only a few small areas along the outcroppings can be mined. There are other locations where the beds are nearer to the surface and could be stripped, but they are thinner (3 to 6 feet thick) than

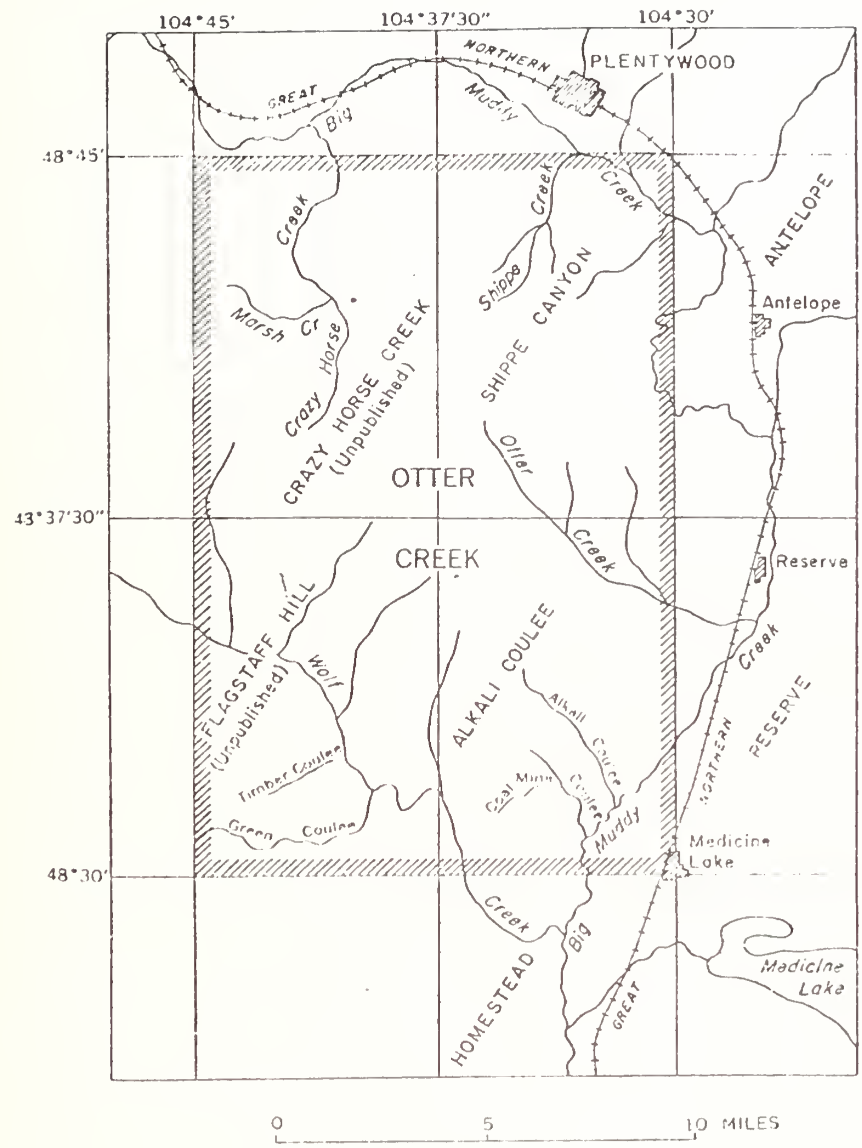


Figure 14. Map showing the Otter Creek quadrangle, the four 7½ minute quadrangles within it, drainage, and nearby towns.

at other locations. The P bed could be stripped; however, it averages only 3 feet in thickness.

No chemical analysis of the coal was available. Many small strip and underground mines were operating to supply the local needs. An old strip mine was located along Green Coulee. Total reserves were estimated at 416 million tons, but there was no estimate of the amount of strippable coal.

13. Northeastern Montana County Survey

A county-by-county report provides information on the total estimated coal reserves[4]. Reserves for the northeastern section of the state are as follows:

County	Total Reserves (Millions of Tons)
Sheridan	5,763*
Daniels	3,964
Roosevelt	4,164*
Valley	257
Richland	21,085*
Dawson	11,110*
McCone	24,871
Wibaux	7,040*

*Incomplete Estimates

When totaled, these coal reserves are in excess of 68 billion tons, but many of the areas have not been explored sufficiently to provide true estimates. Therefore, the values represent a conservative estimate.

A listing of active mines during 1975[5] reported one mine in Dawson County--the Peuse Coal Mine. It is located in Section 13, T 16 N, R. 53 E and employs one person. In Richland County, the Knife River Coal Mine still is in operation in Section 27, T. 20 N, R. 57 E and employs twenty persons. Its mill capacity is 350 tons per hour. Both mines are open pit. No production estimates were reported.

The counties considered in this report are served by the Northern Pacific, Burlington Northern, and Soo Line railroads. Figure 15 depicts the current service provided by these lines to northeastern Montana. Figure 16 is a copy of a road map and shows the highways which serve the area. It may be necessary to provide better transportation to some of the more remote coal fields by building better access roads or establishing railroad spurs.

B. Coal Requirements for a "Hygas" Coal Gasification Plant

The amount of coal required to fuel a "Hygas" gasification plant of the following sizes--250 mm scfd, 180 mm scfd, and 83 mm scfd--is 9.8 million tons/year, 7.1 million tons/year, and 3.3 million tons/year, respectively.[1]

Assuming that the coal supplied to any of the four proposed sites would be supplied locally, coal reserves could be appropriated by county approximately (see Table II).

TABLE II
Coal Reserves of Northeastern Montana

Site	Coal Reserve by County	Total Reserves (millions of tons)	50%** Recoverable
Glasgow	Valley	257	129
New Town-McCone Co.	McCone	24,871	12,436
	Dawson	11,110*	5,555
	Prarie	Unspecified amount available	
	Wibaux	7,040*	3,520
	TOTAL	43,021	21,511
Plenty-wood	Sheridan	5,763*	2,882
	Daniels	3,964	1,982
	TOTAL	9,727	4,864
Popular	Roosevelt	4,164*	2,082
	Richland	21,085*	10,543
	TOTAL	25,249	12,625

* Incomplete estimate
**Assumed 50% recoverable-If strip mining occurs this could approach 90% according to Department of Mining, Montana College of Mineral Science & Technology.

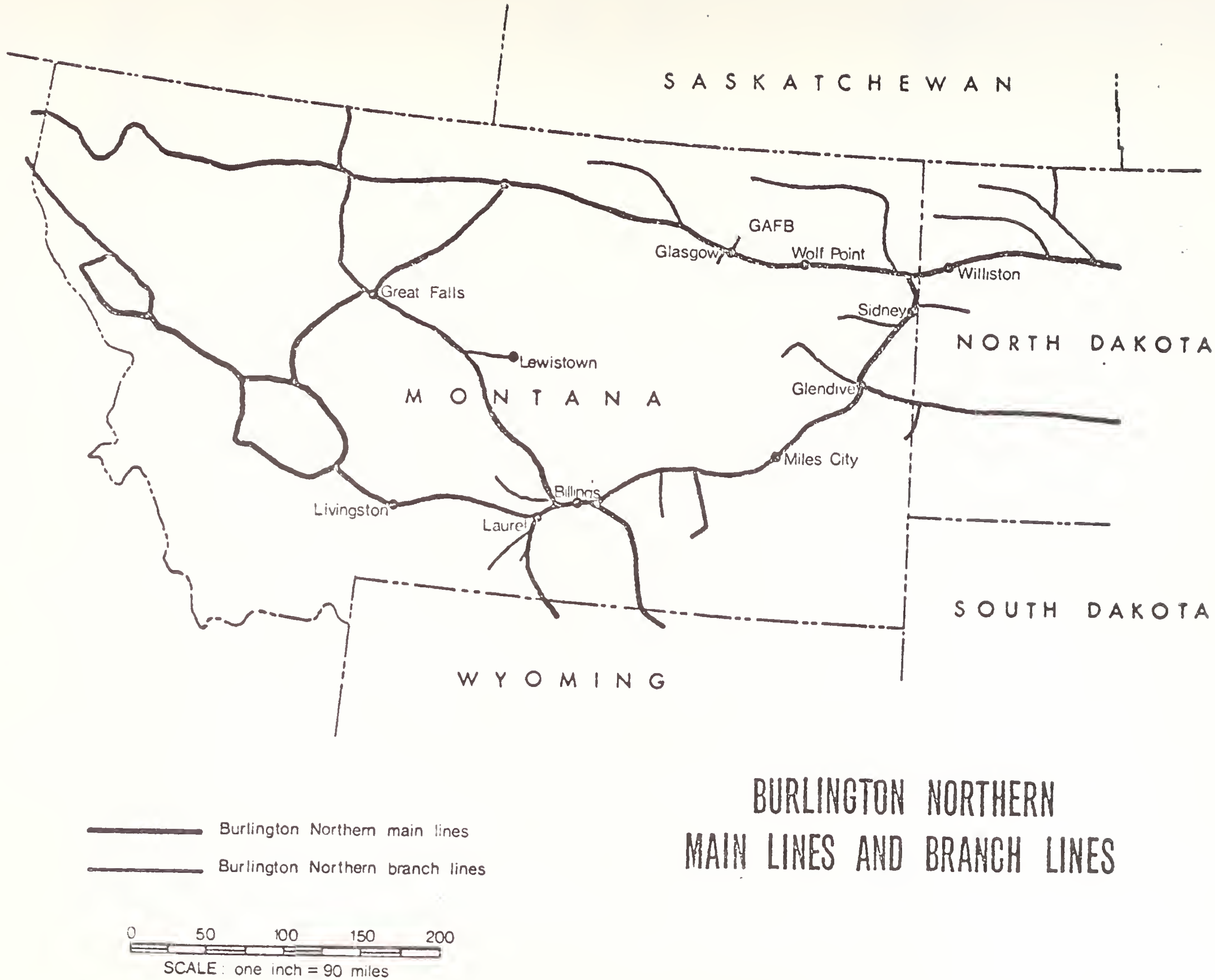


Figure 15. The railroads which serve northeastern Montana.

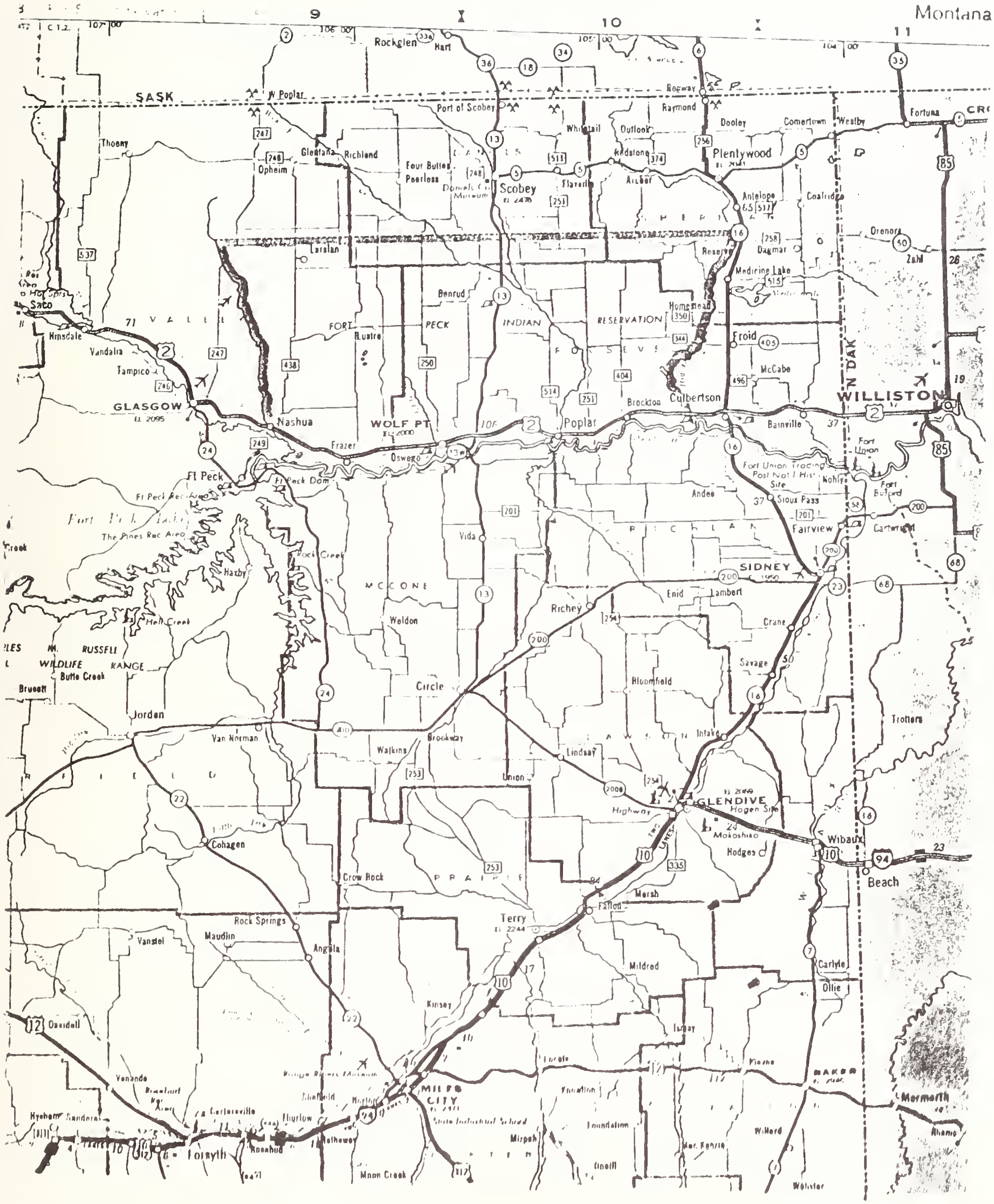


Figure 16. The roads of northeastern Montana.

Present production from these counties includes 25 tons/day from the Snyder Mine in Dawson County and 350 tons/hr from the Knife River Coal Mine in Richland County. On a yearly basis, maximum production at 24 hr/day and 365 days/yr would be 9 thousand tons/yr and 3,066 thousand tons/yr, respectively.

Although coal reserves may be located within a 100-mile radius of the site, they may not be available unless transportation lines exist. It would take a plant requiring approximately 10 million tons of coal per year to justify economically the construction of a 30-mile railroad.[22] Where transportation networks exist it may be economically feasible to transport coal greater distances, providing a longer supply life of coal.

C. High Sulfur Content Coal--The Rosebud-McKay Coal Seams[23]

The Rosebud-McKay coal seams in southeastern Montana are of specific interest to the coal gasification study. The McKay seam (which underlies the Rosebud seam) has sufficient sulfur content to be presently unusable by Colstrip Power Plants 1 and 2. Consequently, the Montana Power Company is mining the Rosebud Coal but leaving the McKay coal in bed. Thus, a vast coal resource is untouched and may be reburied if reclamation proceeds. While unsuitable for a conventional power plant, this high-sulfur coal may be suitable for use in coal gasification. Transportation to a northern site may be costly, but bringing this resource to production may warrant this increased expense.

1. Existing Resources

As far as drillings indicate, the McKay Seam underlies the Rosebud in all areas but does not intermix with the upper seam. The split between the bottom of the Rosebud seam and the top of the McKay seam ranges from 10 feet to over 140 feet. McKay reserves with a maximum split of 60 feet have been delineated and considered for mining purposes. That would total about 70 million tons. At present, there is no contract covering the sale from the Colstrip area to a third party.

The total reserves and location are depicted in Table III--V. The average thickness of coal in areas C, D, And E is approximately 21 to 25 feet for Rosebud and 8.5 feet for McKay.

D. Potential for Unitization in Montana's Coal Industry[25]

As part of this feasibility study, we examined the unitization concept (as applied in recent years to the gas and oil industry) with the specific objective of seeing if there is any applicability to Montana's rapidly developing coal industry.

1. The Concept

The Law of Pooling and Unitization by Raymond Meyers[39] describes the main purposes of unitization as 1) gaining the advantages entailed in having a single operator, 2) eliminating competition, and 3) avoiding duplication of equipment and supervision. Over the years, this concept has emerged as an accepted (and many times required) procedure in the gas and oil industry. An-

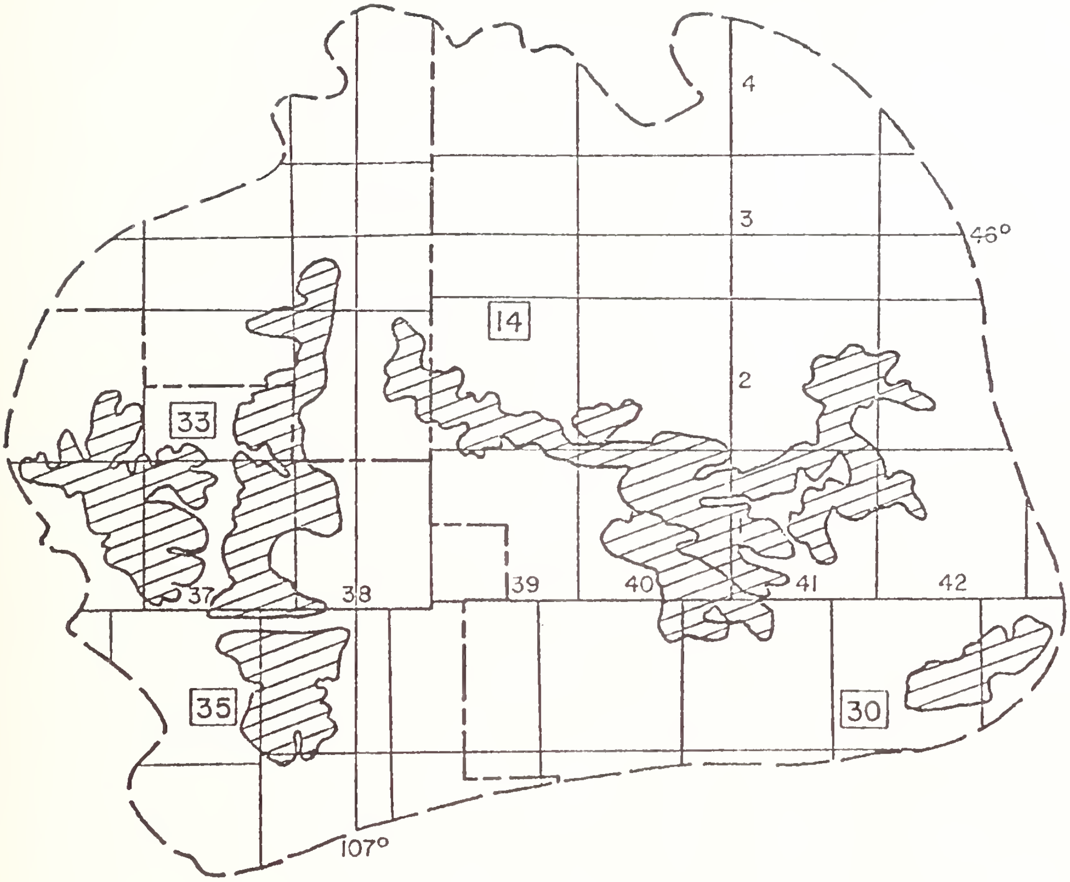


Figure 17. Rosebud-McKay Coal Deposits in Rosebud County, Montana.

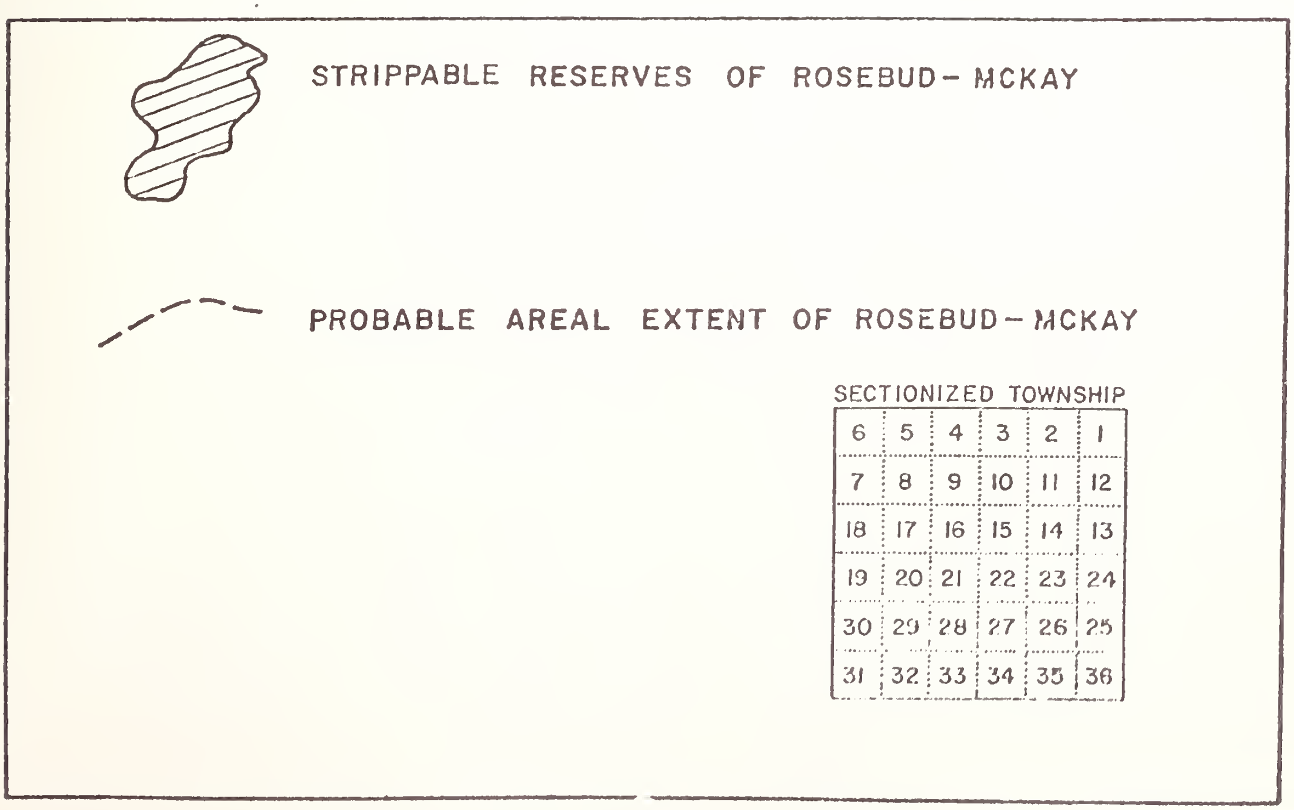


TABLE III

COAL RESERVE ESTIMATES*

ROSEBUD-McKAY SEAMS**

Location	Area Number	Approximate Location	Millions of Tons	Acreage	Coal Seams
Colstrip	No. 14	T1N, R40E, MPM	1,440	33,400	Rosebud-McKay
Greenleaf-Miller Creek	No. 30	T1S, R42E, MPM	455	15,000	Rosebud
Sarpy Creek	No. 33	T1N, R37E, MPM	1,550	42,400	Rosebud-McKay
Little Wolf	No. 35	T1S, R38E, MPM	314	7,400	Rosebud-McKay

*Source: Montana Bureau of Mines and Geology, Butte, Montana.

**See : Figure 17 following.

TABLE IV

McKAY-ROSEBUD

Coal Reserves[24]

	Proven	Leases
Rosebud Mine-Colstrip, Montana		
Rosebud Seam-		
Area A	107,182,000 Tons	
Area B	102,476,000	
Area C	270,000,000	
Area D	119,000,000	
Area E	42,708,000	
Area F (Future)	188,634,000	
	830,000,000 Tons	32,369.49 Ac.

Note: Not included are approximately 100,000,000 Tons of mineable higher sulfur McKay coal below the Rosebud Seam.

	Proven	Leases
Pine Hills Project - Custer, City, Montana		
Dominy Seam		
Burlington Northern and Fee Leases	118,540,000	6,521.88 Ac.
Captive Federal Leases (2541.0)	(79,646,000)	
Westmore Project -		
Fallon City, Montana		
Fee Leases	66,000,000	3,200.00 Ac.
Pennel Creek Project		
Fee Leases	61,129,000	1,760.00 Ac.
Total	1,075,669,000 Tons	43,851.37 Ac.
Include Pine Hills Federal Leases	(1,555,315,000)	(46,392.37)

TABLE V

ROSEBUD and McKAY COAL-SUMMARY

Coal	Recoverable Coal	In Place Coal
Rosebud	790×10^6 Tons	830×10^6 Tons
McKay	67×10^6 Tons	70×10^6 Tons

other way to look at the unitization concept is to veiw it as the consolidation of various mineral interests in an area into one unit so that the particular mineral of concern can be retrieved in the most efficient way possible.

For example, prior to unitizing in the oil and gas industry, competition frequently prevented efficient petroleum extraction. If there were four sections of seprately owned land on which oil and gas were located, it was very possible that each of the four owners would drill a well and attempt to claim whatever resource was beneath his/her land (Figure 18). This activity was precipitated by Law of Capture which stated that if you drilled a well, you could extract whatever reserve would drain to that particular drilling site. Unfortunately this system was grossly inefficient and expensive. By unitizing the four sections into one unit (Figure 19), the reserve could be drilled with fewer wells. This is a very brief illustration of the unit concept; but it explains in a nutshell how the concept has been able to work.

Montana has used the unitization concept in the development of the oil and gas industry for many years. The Oil and Gas Conservation Commission of Montana has supervised the workings of the industry and has been directly involved in establishing units in the state when necessary.

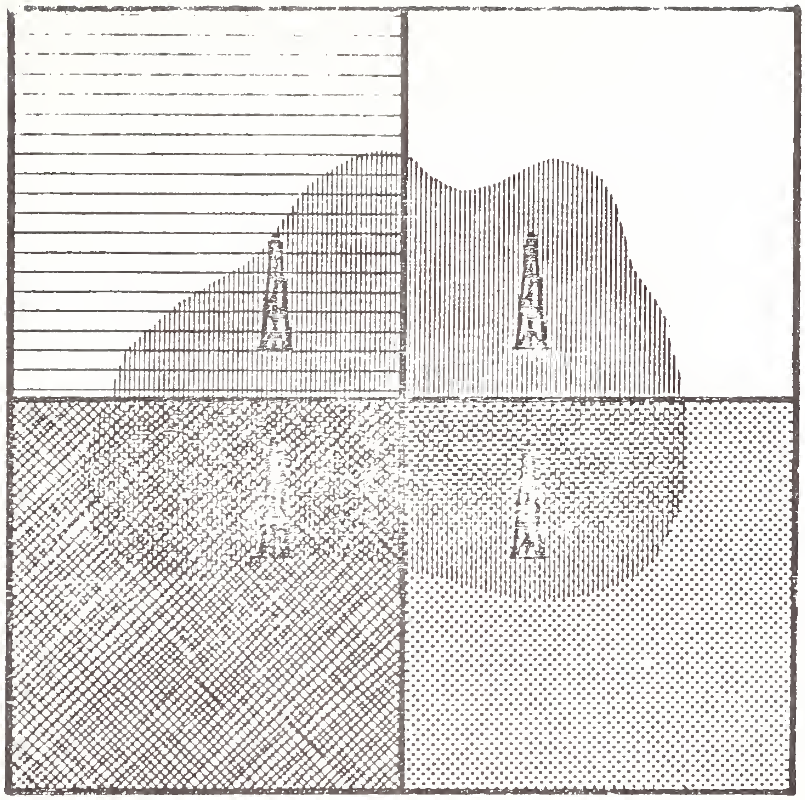


Figure 18. Well Drilling Pattern Prior to Unitization

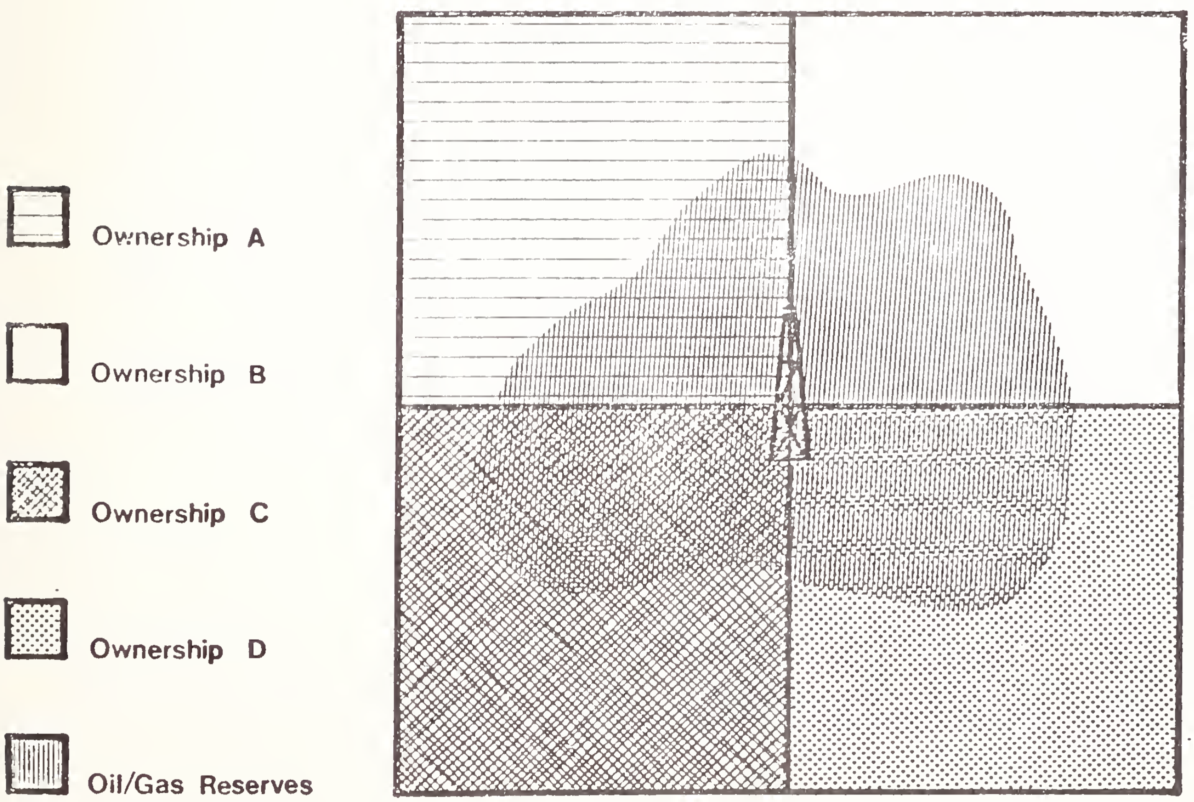


Figure 19. Well Drilling Pattern Following Unitization

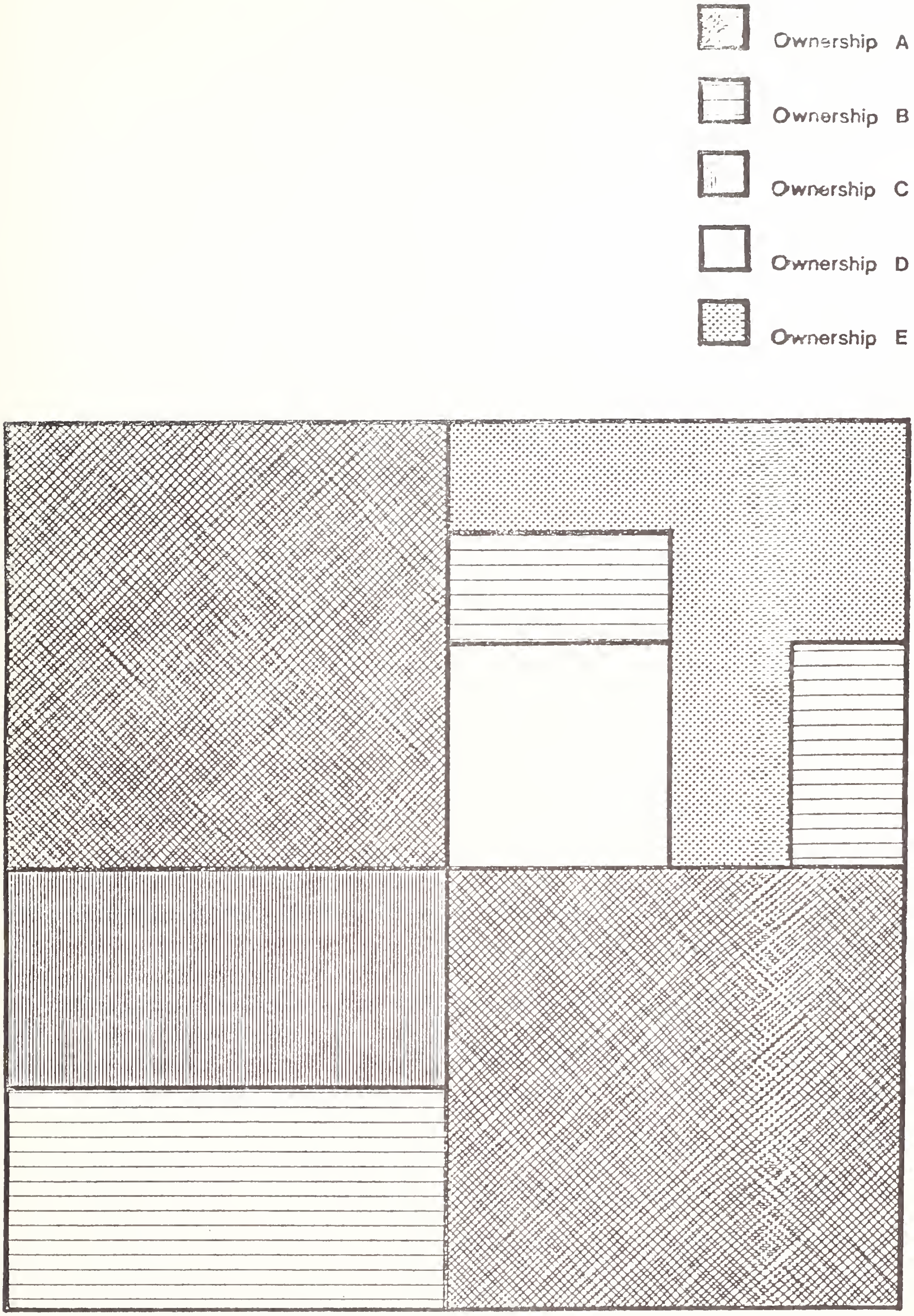


Figure 20. Actual ownership patterns in McCone County, Montana

The concept has proven advantageous to both the mineral owners and the operating entities. This can be demonstrated by the fact that only twice has mandatory participation been invoked by the Commission (according to Richard Hug, Commission Supervisor).

2. Coal Ownership Patterns

The nature of surface and subsurface mineral rights provides another reason for considering coal unitization.

A look at a map showing coal land ownership in Montana reveals a definite checkerboard pattern of coal land ownership. Figure 20 is an example of actual ownership in McCone County. Moreover, it is not at all uncommon to see ownerships on alternating sections throughout a township. The immediate problem with this type of ownership pattern is that if coal is to be mined in the most efficient manner, the determining area of a single operation should be a natural boundary rather than standard U.S. subdivision. The cost of physically setting up a mining operation and the geographical and geological layout of the coal field itself are prohibiting factors. Only infrequently does a complete coal field lie within any one section of land. Even when it does, it is possible that the section may be owned by more than one owner. Since coal land ownership and leases do exist in these patterns, some type of blocking together or unitizing to recover the coal seems logical.

3. Unitizations's Feasibility to the Surface and Subsurface Owner

Advantages

The advantages of a coal unitization program to the surface and subsurface owner would be very similar to the advantages found in the gas and oil industry. One major advantage is that the unit agreement would insure the organization and the coordination of the conservation and reclamation of the unit.

Closely related to land reclamation is land use preservation. This would mean that a farm on one part of the unit would be mined to that particular farmer's interest if those interests corresponded to the unit's general plan. The advantage, then, is that the farmer or rancher has a say in when and how his land will be mined. The unit concept is designed to meet the demands and requirements of all surface and subsurface owners within the unit. However, 100 percent agreement on all that transpires within a unit is impossible to achieve. Therefore, it is important for all interests within the unit to realize that decisions will exhibit the general concerns of the particular unit.

One additional advantage of the unit concept is the financial benefits this unit system can provide. The surface and subsurface owners can spread

their allotments over a period of years instead of receiving a large amount of income only during the specific amount of time when coal is actually being extracted.

The basic idea behind the advance royalty payments is that payments escalate over a specified span of time (for example, a 20- or 40-year period) so that the surface and subsurface owner has been paid for the minerals extracted by the end of the period. Mr. W.H. Ostrecker, Peabody Coal Company representative, explained that as many as 90 to 95 percent of the leases now in existence are set up on the advance royalty plan. This advance royalty system is actually being paid to the surface and subsurface owners now.

Disadvantages

The disadvantages of the unitization concept in the coal industry also parallel disadvantages found in petroleum extraction. Individual rights and interests are diminished when units are formed. An example of this reduction of individual interest was noted earlier. If one owner wants something specifically done with his piece of land that is not in the best interest of the unit, he may have to forego his immediate goal for the good of the unit. Also, depending on how the unitization concept is set up, legislative action may be required. If this is the case, more regulative con-

straint will be imposed on the individual mineral owner than has been experienced previously.

4. Unitization Feasibility for Operating Entities

Advantages

In determining if unitization is applicable to the coal industry, it is beneficial to examine closer how the concept functions in the oil and gas industry and to see if parallel advantages exist for coal.

Mining economics is the one critical variable that dictates whether or not operators would be interested in forming a unit (or, in fact, if they are interested in mining at all). The fewer times equipment has to be relocated, the less capital investment and operating cost must be incurred.

Figure 21 illustrates an area that may never be mined because one section of separately owned land (B) divides the coal field. If the surface and subsurface owner of this strip of land refuses to sign a lease, the coal deposits in the entire section may not be extracted since the mining operation would have to jump from one side of this strip to the other.

Once the mining operation has left the coal field, it is unlikely that it would return to extract this coal. Lands skipped in this fashion represent a wasteful and inefficient method of operation. On the other hand, the coal field

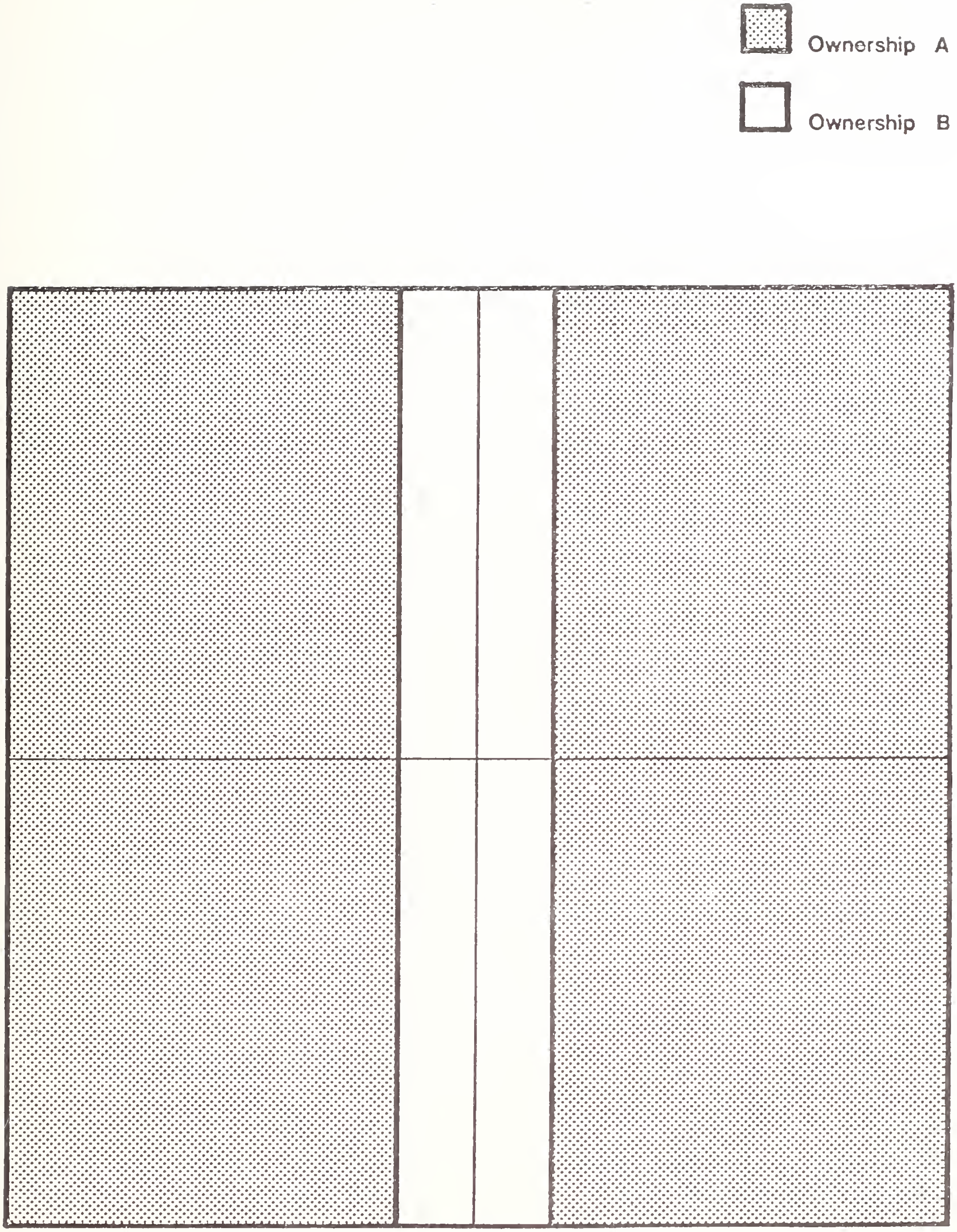


Figure 21. Hypothetical ownership pattern.

could be mined in its entirety if the unitization concept were in effect. No individual ownership boundaries would disrupt the efficient mineral-extraction process.

The process is further complicated by the fact that the operator is dependent on the actual geographical layout of the coal field. While the whole problem of minerals extraction is highly technical in nature, some general conclusion can be drawn.[37] It is imperative that coal fields be set up with the strictest compliance to natural geographic boundaries.

On additional technical consideration is a problem associated with watersheds. If the coal field is not mined in the best possible compliance with geographic and engineering considerations (the watershed being a part of those considerations), excessive erosion might occur because of watershed flow.

In addition to the economic and mining advantages of unitization, the operating entities could benefit by using the unit concept to stabilize the lessor/lessee relationship. If a mining schedule is developed and financial arrangements are planned out, a well-coordinated unit will evolve. Seeing this stable organizational structure, mineral owners will be less likely to withdraw their leases.

Since the operator is responsible for reclaiming the land once the coal is mined, a coordinated and systematic unit program would be a definite advantage. Also, unit boundaries are not dependent upon ownership (but rather on the boundaries of the most logical mining area); the reclamation that would follow mining also would follow that particular geographical layout.

This approach to reclamation is much more effective than attempting piecemeal reclamation. Many of the same problems involved in mining an area apply to the reclamation program. For example, it is inconceivable that mining one 40-acre field and then jumping to another 40-acre tract would be economically feasible. In a similar manner, land reclamation requires the same coordinated approach. The constant moving and setting up of equipment and inability to conform to the geographic layout of the land does not make for the best reclamation system.

5. Unitization and the Public Interest

Public advantages

Energy conservation is a matter of prime concern in this day and age. Therefore, it is significant that the unit approach has proven a more resource-efficient manner of obtaining raw material. In the preceding sections, we have shown how the unit system developed for the petroleum indus-

try also can increase efficiency in the mining industry. For one thing, unitization can directly benefit the general public through the conservation of coal. By recovering coal in logical and economical blocks, the resource can be mined with a minimum of waste and at the minimum cost per ton.

Another major advantage of the unit system is its capacity to coordinate land disturbance, resulting in fewer acres of land to be stripped and reclaimed. Reclamation efforts can be focused on a smaller area and probably would net a better total effort ecologically. Certainly this minimization of environmental impact is in the best interest of the public. With the unit concept, theoretically, lands are mined and reclaimed in the most coordinated effort possible. Moreover, the optimum amount of strippable coal is mined, and waste is reduced to a minimum.

Public disadvantages

Although many direct and indirect benefits are associated with the unit system, some disadvantages do occur. The time and expense associated with forming a larger unit could cause substantial delays in mining and increase costs of the mining operation. This increased cost ultimately will be passed on to the consumer--the general public.

Some form of enabling legislation would have to be drawn and passed to provide the legal frame-

work for the unit concept. While this legislation is a positive "door opener", it may be viewed by the public as another example of government regulation and associated bureaucratic interference. The power and authority to regulate and administer the unitization law means more government and more of what goes along with it (i.e., rules, paperwork, red tape, taxes, etc.).

E. Coal Transportation[26]

Potential conversion sites have been identified as Glasgow Air Force Base, New Town(to be located in McCone County), and Poplar--with mines located on the Circle West, Redwater, and Fort Kipp seams. The absence of navigable waterways and the relatively short-haul distances involved in this case preclude the movement of coal by barge. This leaves two alternative modes of transportation with the potential for transporting required volumes of coal from the mine mouth to the remote conversion sites at either Glasgow Air Force Base or Poplar.

These two transportation modes are unit trains and coal-slurry pipeline transmission. Both modes are technically feasible and operable. Although positive factors are associated with the use of slurry pipelines, this mode of transportation is not viable in Montana because of state constitutional restrictions. The 1972 Montana Constitution excludes water use in coal-slurry pipeline operations. Since legislative action could alter this situation, both modes are discussed in the following sections.

1. Unit Train System

A unit train normally is composed of one hundred cars with an individual car capacity of 100 tons. The train is loaded at the mine mouth and unloaded at one consuming site.[27] Each train is capable of transporting 10,000 tons per day or 3,650,000 tons per year if the distances involved require less than 24 hours for movement to the site, turn-around, and maintenance.

One hundred ton-capacity hopper cars cost approximately $25,000 new. Diesel locomotives range in cost between $400,000 and $500,000 with 4 diesels required per 100-car train. The 1976 estimated cost of a new 100-car unit train is approximately $4.5 to 5.0 million.[28] Required coal tonnages and the number of unit trains necessary per day are indicated below:

Gas Process	Size (MMscfd)	Coal Requirement Million Tons/Year	Unit Train Req (Trains/Day)
LURGI	250	10.3	2.8
	180	7.4	2.0
HYGAS	250	9.8	2.7
	180	7.1	1.9
	83	3.3	.9

2. Coal Slurry Pipelines

Coal slurry transmission consists of a pipeline which transports fine coal (smaller than 8" mesh) in a water solution. Slurry is pumped at low velocity (usually less than 3½ miles per hour) under pressure through the pipe to its terminus. Pumping stations are required at 50 to 100 mile intervals to assure constant flow.

A slurry pipeline system entails three primary operations. Coal first is crushed by impactors and ground into fines. These are combined with an equal volume of water and fed into agitation tanks to maintain suspension of the coal particles. The slurry is then introduced into a pipeline where it is pumped to the consuming site. At the lines termination, slurry flows into settling tanks where it is initially dewatered. It is then either vacuum dried or fed into a centrifuge where the remaining water is captured and removed. Depending upon the technology used or how the coal is to be handled, further drying may be required. The water used for transmission is poured into a filtration plant where inpurities and pollutants are removed. At that point, the water is fed into the industrial plant either as make-up water for cooling or for use as the source of process hydrogen or oxygen. The water requirements necessary to transport the necessary volumes of coal for the synthetic gas facility are listed below:

TABLE VI
SLURRY PIPELINE WATER REQUIREMENTS

Gas Process	Size (MMscfd)	Coal Requirement mm tons/yr.	Water Use For Transmission (acre feet/yr)
LURGI	250	10.3	6,180
	180	7.4	4,440
HYGAS	250	9.8	5,880
	180	7.1	4,260
	83	3,3	1,980

Slurry pipelines typically are buried two to three feet underground. The surface above the line is reclaimed and returned to its previous use, minimizing environmental impact. Permanent land use associated with pipeline development is limited to processing facilities at each terminus and pumping stations required at intervals along its route.

3. New Town, McCone County

Conversion sites on the Redwater and Circle West seams do not require a formal transportation system. If a mine-mouth site was selected for the processing facility, coal could be transported by truck or with a series of conveyors to the coal preparation and storage area.

4. Poplar

Since the Poplar site is adjacent to the Missouri River, there is adequate access to water resources. If the mine was located on the Redwater seam, the water necessary for a slurry pipeline would be diverted from the river to the mine location. This would require a twenty-three mile water acquisition pipeline. A twenty- to thirty-mile water line would be developed from the Fort Peck Reservoir if coal was secured from the Circle West seam. A 65-70-mile slurry pipeline then would be developed to Poplar.

Additionally, coal taken from this field could be extracted, loaded, and shipped by unit train be-

tween the coal field and the consuming site. This would necessitate an investment of two to four million dollars for spur development.

Thirty miles east of Poplar is the Fort Kipp coal seam adjacent to the Missouri River. Water could be acquired from the river through a two- to three-mile pipeline to the mine and the slurry transported to Poplar by a thirty-mile pipeline.

Coal transportation via unit train from the Redwater or Circle West seam could be accomplished with the development of a rail spur to the old Great Northern tracks slightly west of Wolf Point.[29] Cost estimates for this rail development are presented below:

Approximate length	:	54.8 miles
Grade	:	less than 1%
Approximate Gross Cost	:	$36,000,000

54.8 track miles with new 115LB continuous track:	$ 6,305,000
Sled Ballast - 54.8 miles crushed rock	$ 749,000
1,200 ties per mile	$ 829,828
Bed establishment, Bridgework, etc.	$28,500,000

If Poplar is selected as the site for the gasification facility, feedstock necessary for plant operations should be acquired in the Fort Kipp coal field. Factors involved include short-haul distances and proximity to both water and rail lines. Only minimal investments would be required to develop the nec-

essary transportation infrastructure to transport the required volumes of coal for all processes and size ranges. It appears that unit train shipment would provide the most cost-efficient transportation in this instance.

5. Glasgow Air Force Base

Distances form the selected mine sites utilizing the various modes of transportation are displayed below:

<u>GAFB to Circle West Seam</u>

Coal Slurry Pipeline	
Water Acquisition	25 miles
Slurry Pipeline	70 miles
Unit Train	
Alt. 1 new bed, etc.	55 miles
Existing trackage	68 miles
Alt. 2 new bed, etc.	25 miles
Upgrading (Circle-Glendive) Existing trackage	52 miles

<u>GAFB to Redwater N.W.</u>

Coal Slurry Pipeline	
Water Acquisition	23 miles
Slurry Pipeline	75 miles
Unit Train	
New bed	55 miles
Existing trackage	68 miles

<u>GAFB to Redwater N.E.</u>

Unit Train	
Upgrading (Richey-Snowden) Existing trackage	75 miles

GAFB to Fort Kipp

Coal Slurry

Water Acquisition	143 miles
New trackage	

The Fort Kipp coal seam represents the lowest capital cost for an additional transportation infrastructure. If a unit train was utilized, a three to five mile spur would be required. A junction with the existing rail line between Fort Kipp and Culbertson also would be required. Direct cost for coal shipment would be on the order of $.85/ton computed at 0.6 cents per revenue ton mile.

Transportation distances for both coal slurry pipelines and unit trains from the Redwater and Circle West seams are roughly comparable.

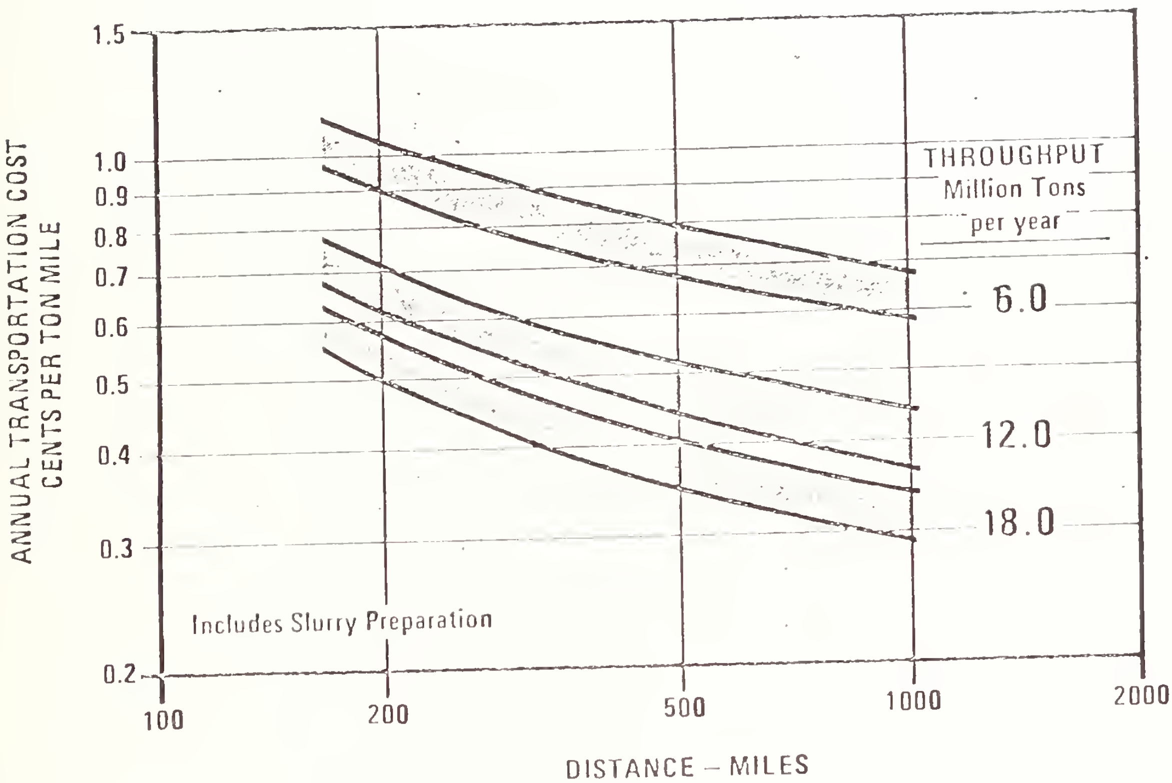
Unit train coal transportation costs could be above 0.6 cents per revenue ton mile based upon construction costs and traffic volumes for the new rail spurs. At that distance, utilizing 0.6 cents transportation cost per revenue ton mile, costs would be approximately $.75 per ton.

Slurry pipelines tend to be more sensitive to volumes shipped and distances than unit train transportation. As throughput and distance increase, costs per ton decrease in an inverse fashion. Figure 22 is a graph representing this association.

If a remote site is selected for the gasification facility, coal-feed requirements will tend to indicate

Figure 22

Coal Slurry Pipeline Transportation Costs



which transportation mode is most cost effective. However, unit-train transportation would be desirable if coal requirements are below this level and the coal acquisition site is adjacent to existing rail services. Slurry pipeline transport could be the preferred mode if through-put requirements are determined to be above the eight million ton/year level.

Transportation costs reflect less than ten percent of the cost of coal feed at these identified distances. A general observation is that at the 10 percent level, transportation cost is not of overwhelming significance in the siting of the gasification facility. The Fort Kipp field displays transportation advantages for both of the remote sites. Either it reduces transportation distances (Poplar site), or it decreases capital cost investments (Glasgow site). If coal cannot be secured from the Fort Kipp field, the Redwater or Circle West seams offer approximately equal transportation incentives. Without new track development, the N.E. section of the Redwater (in the vicinity of Richey, MT) would provide low capital investment incentives. Track upgrading of this route would cost approximately 12.8 million dollars (see Figures 23 and 24).

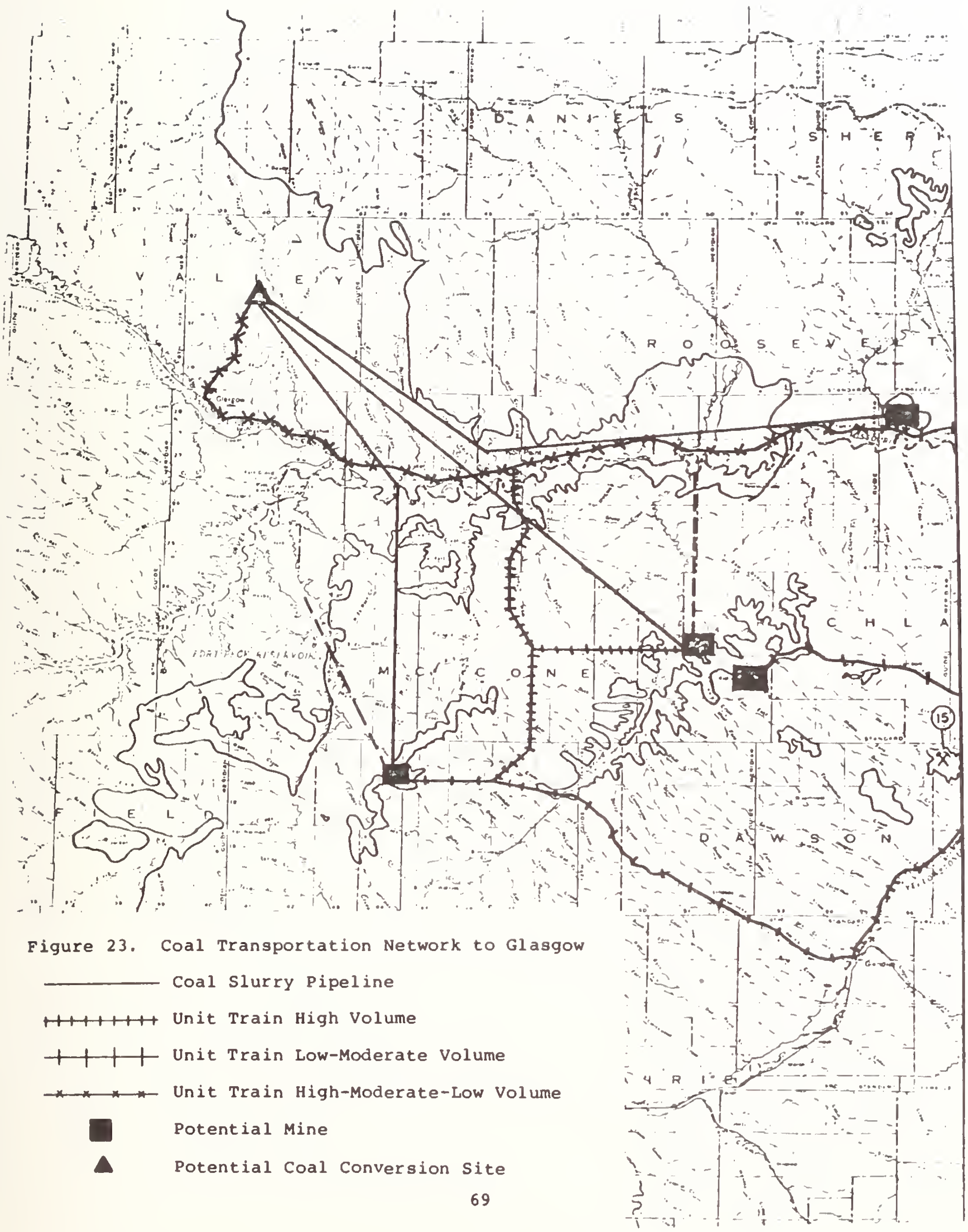


Figure 23. Coal Transportation Network to Glasgow

- Coal Slurry Pipeline
- Unit Train High Volume
- Unit Train Low-Moderate Volume
- Unit Train High-Moderate-Low Volume
- Potential Mine
- Potential Coal Conversion Site

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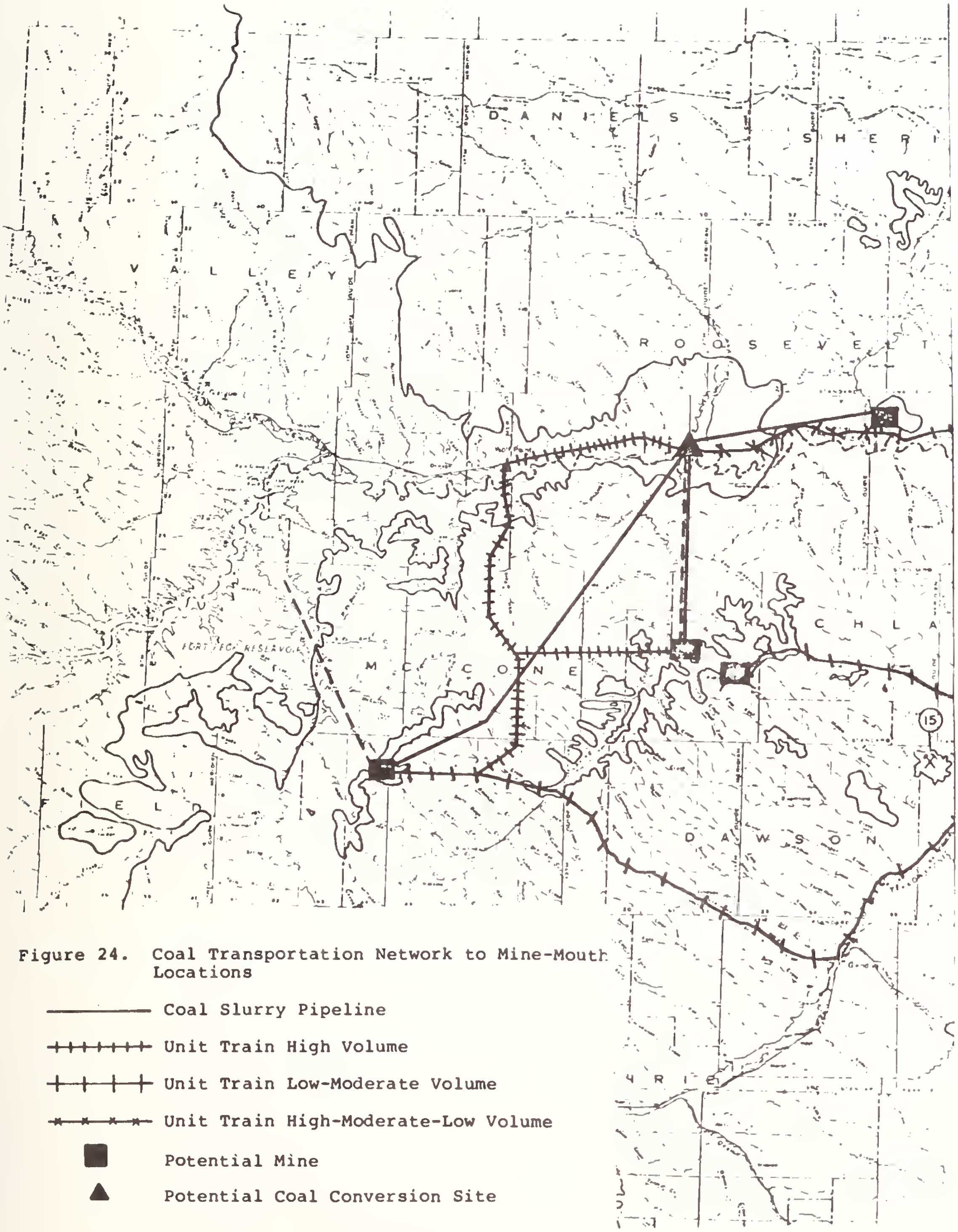

Figure 24. Coal Transportation Network to Mine-Mouth Locations

Coal Slurry Pipeline

Unit Train High Volume

Unit Train Low-Moderate Volume

Unit Train High-Moderate-Low Volume

Potential Mine

Potential Coal Conversion Site

V. WATER RESOURCES

This section identifies the requirements, potential source(s), means of transporting, and costs of process and cooling water for variable sizes of "Hygas" coal gasification plants.

Assuming a linear relationship exists among the water requirements for various plant sizes and that evaporative-cooling towers are employed, approximate requirements appear in Table VII.

A. Water Requirements for Coal Gasification Plant and Accompanying Irrigation Project[30]

Water requirements for the "Hygas" coal-gasification process were calculated assuming evaporative tower use.[1] A 250 mm scfd SNG plant requires approximately 16,000 acre-feet per year (Table VI). In addition, water requirements were estimated for an accompanying irrigation project at each of the four hypothetical sites (Glasgow Air Force Base, New Town-McCone County, Plentywood, and Poplar).

Maps showing existing irrigated and potentially irrigable land in the vicinity of the four plant sites were obtained from the Water Resources Division of the Montana Department of Natural Resources in Helena. Potentially irrigable land was classified into three categories regardless of water supply. The characteristics of categories applicable to northeastern Montana are explained in Appendix A.

New irrigation requirements for alfalfa, corn, small grains, and grass hay were weighted by their respective acreages in Valley County as reported in the 1969 Census of

V. [illegible]

[illegible]

New irrigation [illegible]

grains, and these may [illegible]

ages in Valley County as reported [illegible]

TABLE VII-HYGAS PLANT AND IRRIGATION WATER SYSTEM DATA

Plant Size and Location	Length of Pipe (miles)	Elevation Difference (feet)	Irrigable Acres	Water Requirements for Irrigation (acre-feet/yr)	Water Requirements for Hygas Plant (acre-feet/yr)	Total Water Requirements (acre-feet/yr)	Pipe[1] Size Diameter Gage	Total[3] Head (Feet)	h_1 [2] Ft/1000ft	HP [4]
250 mm/scfd 9.8 mm tons/yr										
GAFB	24.5	720	39,636	86,406	15,950	31,900	36"-3	1157	3.38	5,785
New Town	31	324	5,710	13,497	15,950	29,450	36"-3	797	2.89	3,679
Plentywood	43	190	137,531	342,967	15,950	31,900	36"-3	958	3.38	4,790
Poplar	.5	50	None	None	15,950	15,950	30"-3	57	2.60	143
180 mm/scfd 7.1 mm tons/yr										
GAFB	24.5	720	39,630	86,406	11,490	22,980	36"-3	966	1.90	3,458
New Town	31	324	5,634	13,497	11,490	22,980	36"-3	635	1.90	2,287
Plentywood	43	190	137,531	342,967	11,490	22,980	36"-3	622	1.90	2,240
Poplar	.5	50	None	None	11,490	11,490	28"-3/16	55	1.90	99
83 mm/scfd 3.3 mm/tons/yr										
GAFB	24.5	720	39,630	86,406	5,300	10,600	28"-3/16	940	1.70	1,561
New Town	31	324	5,634	13,497	5,300	10,600	28"-3/16	603	1.70	1,002
Plentywood	43	190	137,531	342,967	5,300	10,600	28"-3/16	576	1.70	957
Poplar	.5	50	None	None	5,300	5,300	16"-12	61	4.20	51

1. Determined From - Handbook of Water Control 1936, The Hardestry Manuf. Co., Lederer, Street and Zeus Co. Inc., Soil Conservation Service Document--Technical Guide, Section IV, Standards & Specifications, A-J, Dec. 1968 and Charts No. Mt, L-031,010.0, and 010.11.
   All figures are for welded steel pipe- n=.012.

2. Friction losses - this range minimizes total pipe and pumping costs.

3. Water velocity assumed 5 fps to prevent water hammer effect from irrigation valves. Operating head was assumed negligible.

4. Horse-power - requirement does not include increase caused by pump efficiency.

Agriculture.[31] The net irrigation requirements used were specifically for climatic area II as defined by the Reconnaissance Land Classification Specifications of the Montana Department of Natural Resources. The counties of Valley, Daniels, Sheridan, Roosevelt, McCone, and Richland are contained in this area. The specific acreages and net irrigation requirements are reported in Appendix B. A canal loss of .76 acre-feet per year (40 percent of the diverted flow) was added to this net irrigation requirement. These values were determined in a resource feasibility study for the U.S. Department of Commerce. Utilizing these assumptions, an average yearly requirement of 3.06 acre-feet was obtained. This figure is very close to that determined in Reference 32 and was used as the diversion requirement for land classes I and II. Class III land can be irrigated only with sprinklers. Sprinklers have an efficiency of 70 percent, which is considerably higher than gravity irrigation. Therefore, the average yearly diversion for class III land was assumed to be 2.18 acre-feet.

Site specific water requirements are discussed in the sections which follow.

1. Glasgow Air Force Base

There is an existing water pipeline between the Missouri River (two miles below Fort Peck Dam) and Glasgow Air Force Base. Any pipeline associated with an SNG plant likely would follow the same route. Glasgow AFB is located between Cherry Creek and Porcupine Creek. These streams run parallel to each other and are about

10 miles apart. The existing pipeline runs between these two drainages where there is an estimated 39,636 acres of potentially irrigable land. At least 95 percent of this land is class III. If all this land were to be irigated, 86,400 acre-feet of water would be required. Therefore, to estimate the water requirements, we assumed that irrigation requirements would be no larger than that required for the Hygas plant. Total water requirements for a 250 mm scfd plant at Glasgow AFB would be about 38,700 acre-feet per year. Estimated water requirements for a 250 mm scfd, 180mm scfd, and 83 mm scfd plant are given in Table VI.

2. New Town--McCone County

For report purposes, we assumed that the New Town Hygas plant would be located in section 6, range 49 east, township 19 north about 2.5 miles northeast of Circle. This site was chosen for expository purposes only, and it is not to be implied that this is where the plant would or should be constructed. Similarly, we assumed that the source of the pipeline would be in section 26, range 43 east, township 21 north at the confluence of Nelson Creek and Fort Peck Reservoir. Such a location would require a 31-mile pipeline.

Section 6 was chosen hypothetically because of its proximity to a Northern Pacific railroad spur, the Redwater Creek coal field, and Circle. The Rickey-Lambert coal field begins one township north and one range east, just a few miles from Circle.[3] A few areas of this field

have only 50 feet of overburden and are 5 feet thick. Such areas may be strippable. But more importantly, the whole area is underlain by the Fort Union formation. It generally is accepted that strippable deposits are located along Redwater Creek northeast of Circle to township 20 north, range 49 east with the bed ranging from 8 to 21 feet thick. Estimates are that 642 million tons of strippable coal lie under 150 feet of overburden.[3]

Approximately 5,710 acres of potentially irrigable land are within 5 miles of the hypothetical pipeline route and within a drainage traversed by the pipeline route. Approximately 1,194 acres are class II, with the remainder being class III. Water requirements for these acres would be 13,497 acre-feet per year. Total water requirements for a 250 mm scfd plant at this location would be about 31,900 acre-feet per year. Values for the three plant sizes are given in Table VI.

3. Plentywood

Another hypothetical site is near Plentywood. Its legal description is section 29, range 55 east, township 161 north. The pipeline is assumed to begin at the Missouri River in section 27, range 55 east, township 28 north. The 43-mile pipeline would require a lift of only 190 feet. This particular location was chosen as a reference point because of its proximity to a railroad and its position to several coal fields.

Section 29 is on the western edge of the Culbertson lignite field. About 9.3 billion tons of low-grade coal are recoverable through mining. The section is located near the northeastern edge of the Fort Peck Indian Reservation lignite field and the eastern edge of the Scobey field. It is not known if the Fort Peck field is strippable, but the Scobey field has beds 3 to 6 feet thick within 500 feet of the surface. The Otter Creek Quadrangle (just south of Plentywood and containing section 29) has some coal beds 3 to 6 feet thick which could be stripped.[3]

Along the pipeline route, there are 13,298 acres of class I land, 35,735 acres of class II land, and 88,498 acres of class III land--all of which are potentially irrigable. If only the class I land is irrigated, water requirements will be 40,692 acre-feet per year. It would require 342,967 acre-feet annually to irrigate all the potentially irrigable land. Since it is unlikely that water would be supplied to all this land, the total water requirements for each size of "Hygas" plant is calculated assuming that the maximum irrigation water supplied would be no more than the water requirement for the plant. Totals are shown in Table VI.

4. Poplar

The final site considered in this study is located near Poplar. This hypothetical location is in section 30, range 53 east, township 28 north. This site was

used for analytical purposes because of its proximity to the Missouri River, the Great Northern railway, and the Fort Kipp coal field. The Fort Kipp field covers townships 28-29 north and ranges 53-55 east and is overlain by the Fort Peck seam which averaged 5.4 feet in thickness. In places, the Fort Peck seam lies within 11 feet of the surface and, therefore, would be ideal for strip mining. Approximately 245 million tons are overlain by 125 feet or less of overburden.

There are no irrigable acres surrounding the Poplar site, resulting in a total water requirement for the 250 mm scfd plant of 15,950 acre-feet per year.

The question of suitability for irrigation is dependent on a variety of considerations--not merely soil characteristics or water availability.[33] A study conducted for McCone County to evaluate the agricultural irrigation applicability of the Circle West development concluded that supplying irrigation water in conjunction with an individual pipeline was economically infeasible. This calculation indicated that considerable subsidation ($16.00 per acre-foot) would be necessary to make industrial pipeline water economically attractive for agricultural irrigation.

B. Potential Sources of Water[33]

From the standpoint of physical availability, more than sufficient water is available from either the Fort Peck Reservoir or the Missouri River to supply maximum water needs of the largest coal gasification facility envisioned by this

study. The primary unsolved questions at the present time include 1) the legal availability of the water, 2) right to transport water across the C.M. Russell Game Range, and 3) regional water requirements and priorities. These questions are discussed in the following sections.

1. Surface Water

The only sources of water sufficient for gasification plants in northeastern Montana are the Missouri River and/or the Fort Peck Reservoir. Legal rights to the surface waters of the Missouri River and the Fort Peck Reservoir are not defined at the present time.

As one example of this, a resolution by the Fort Peck Tribal Executive Board (representing the Assiniboine and Sioux Tribes) declares in part "That the tribes are the owners of the first, paramount and immemorial rights to all water, including those on the surface and underground, occurring on, arising upon, passing through or bordering upon the Fort Peck Indian Reservation of Montana."

A second example involves the Major River and Harbors Act which presumably restricts the amount of water that can be withdrawn from surface water to 100 acre-feet/year.

Until these questions (as well as the equally important issues of regional priorities, interbasin transfers, and the rights of downstream users) are resolved either legally or legislatively, the question of hydrologic availability cannot be addressed in any final way.

2. Groundwater

The only aquifer potentially capable of supplying the volumes of water required for the coal gasification facilities is the Madison Group of Mississippian age, lying at a depth of 5000+ feet. At the present time, this is an extremely speculative water source. No single well or group of wells has been developed in the Madison group with a capacity of 13,900 to 55,600 acre-feet/year. There is good reason to believe that extracting this volume of water from the Madison limestones would produce regionally significant drawdowns extending into the Dakotas, southern Montana, Alberta, and Saskatchewan.

Also, the TDS (total dissolved solids) of the water in the Madison group range up to 300,000 ppm (parts per million) under portions of northeastern Montana. While the TDS values immediately beneath Glasgow AFB are less than this, continued pumping undoubtedly would establish a gradient that would draw water with a higher TDS content to the pumping site.

Until proven empirically, grounwater cannot be considered a feasible source of industrial water.

C. Water Transport[33]

The only feasible means of transporting water to a coal conversion facility is a pipe aqueduct system originating either at the Fort Peck Reservoir or downstream from the Reservoir on the Missouri River.

In transporting water from the Fort Peck Reservoir, consideration should be given to the fact that it is completely surrounded by the C.M. Russell Game Range. This game range was established on lands obtained from the Corps of Engineers at the time of the reservoir's construction. Presently, the game range is administered by the U.S. Bureau of Wildlife and Sport Fisheries. A spokesman for Burlington Northern indicated that they plan to transport water across the same range through a corridor designated at the time the game range was established. Spokesmen for the U.S. Bureau of Wildlife and Sports Fisheries and the Corps of Engineers were unwilling (or unable) to confirm the existence of these corridors.

Whether or not such corridors exist, the construction of a pipeline across the C.M. Russell Game Range will produce a strong reaction from conservation interests and may not be a politically or economically acceptable alternative in the foreseeable future.

D. Water Costs[33]

The costs associated with aqueduct systems from any of the four sites are dependent on specific routes. Since these have not been determined, only rough estimates can be made.

A reconnaisance investigation of 30 potential pipeline routes in southeastern Montana conducted by the Bureau of Reclamation produced cost figures ranging from a high of $4,069,000/mile for construction and $60,900 per year for operational costs to a low of $652,000 per mile for construction and $8,200 per year for operations. The mean construction

cost for the routes was $1,791,000 per mile with the median being $1,560,000. The mean operational cost was estimated to be $20,000/year.

Referring to Table VI, the cost/yr of the 36"-3 gage pipe to supply 31,900 acre-feet/year at 24.5 miles is about $730,000 while the pumping cost is approximately $731,000.[34] The total of $1,460,000/year does not include the costs of pumps or substations. Types and costs of pumps will vary with site specifications.

For lower flow rates, other types of pipe with different costs may be substituted. Additional costs such as special coatings needed because of soil resistivity and water ph were not determined since these characteristics were unidentified. Until site decisions are made, specific costs cannot be determined.

Direct cost of industrial water was specified in an agreement between the state of Montana and the U.S. Bureau of Reclamation (USBR). According to a Bureau spokesman, they have agreed to sell Montana water at a rate of $20 per acre-foot on an annual basis. Another DNR source stated that it would be state policy to sell water from the Missouri River for not more than $40/acre-foot.

Agricultural irrigation water presently is available from developments such as Fort Peck Irrigation Project at a cost of approximately $4.00 per acre-foot. This project supplies water only at sites in close proximity of the river downstream from the dam.

VI. PRODUCT DISTRIBUTION

Dependent upon the volume output of the coal gasification facility and its location, gas transmission costs can be computed. A gas transmission pipeline would traverse the distance between the plant gate and existing transmission lines possessing adequate capacity to accept an additional volume of gas. In this case, the Montana Power Company's main line between the Canadian border and Augusta, Montana, is identified as the most acceptable option.

Gas transmission pipelines are usually buried three to four feet below the surface; therefore, land utilization (except for compressor stations) is minimal. The surface above the pipeline is reclaimed and returned to its former use. Minimal environmental disruption would occur in association with the pipeline.

A. Existing Physical Capabilities

1. Montana Power System

Presently, the Montana Power Company operates one twenty-inch pipleine which extends from Cutbank, Montana to a junction west of Helena. This line is Montana Power's primary transmission distribution line from its supply source in Alberta. If, as expected, the Canadians curtail exports, this line will have an excess capacity of approximately 150 mm scfd. Through this supply line, gas is transported to the Helena, Missoula, Great Falls, Butte, and Bozeman areas.

Other junctions within the Montana Power Company system would result in acceptance of less than 150 mm scfd and could not be readily distributed.

2. Montana Dakota Utilities

Montana Dakota Utilities (MDU) operates a six-inch pipeline into Glasgow Air Force Base and an eight-inch pipeline through Glasgow and Wolf Point. The six-inch pipeline is a supply line to Glasgow Air Force Base. The MDU eight-inch line is an acquisition line that transports natural gas from the Bowdoin natural gas field to other lines within the MDU system (at a juncture north of Glendive, Montana). A twelve-inch pipeline extends from a point in north central Fallon County (north of Baker) to the Billings area. This main line will present a logical opportunity for gas distribution if synthetic natural gas is to be delivered in eastern Montana.

B. Synthetic Natural Gas Output

The preliminary feasibility program for coal gasification has identifed three possible plant sizes for devlopment. Facility sizes and output are computed on the chart:

Daily Output (Million Cubic Feet)	*Yearly Output (Billion Cubic Feet)
83	27.4
150	49.5
250	82.5

*Yearly output computed on a 330-day operating year.

Estimates are based upon the throughput capacities as indicated above.

C. Pipline Junctions and Costs

1. General Observations

The output of a 250 mm scfd facility would surpass the system capabilities of the Montana Power Company. Therefore, the distribution of the synthetic gas product would require utilizing the Montana-Dakota system or the development of an interstate pipeline for gas sales. Eighty-two and five tenths BDF surpasses total 1975 Montana natural gas demand by approximately seven to eight BCF.

It should be noted that developing any lines to the Montana Power Company mainline will not impact any protected lands (national forests, parks, wildlife reserves). Also, the areas to be traversed are remote from population centers for the most part.

2. Glasgow Air Force Base

A pipeline-junction location with the Montana Power system has been determined. The connection will be the main line at compressor station number two which is located southwest of Conrad, Montana. This would require 275 miles of new pipe with a maximum through-put capacity of 150 mm scfd. For 150 mm scfd, a twenty-inch pipeline at Glasgow with a pressure base of 960 psig could be developed for approximately 35.5 million dollars. An output of 83 mm scfd would require a 16-inch pipeline and would cost approximately 28.2 million dollars to develop (see Table VIII).

3. Poplar

To transport 83 mm scfd from the Poplar site would require a 350-mile, 16-inch pipeline at an estimated direct construction cost of 36.6 million dollars. Maintaining the pipeline would require an additional expenditure of $685,000 per year. A 20-inch pipeline sufficient to transport 150 mm scfd would cost approximately 46.8 million dollars for the 350-mile development. This line would intersect with the Montana Power system at main line compressor station two.

4. New Town, McCone County

The McCone county site would require a similar product transmission system. The pipeline length would be approximately 350 miles for both 16- and 20-inch lines. The 83 mm scfd line would cost 37.25 million dollars with $820,000 required to operate and maintain the line per year. The 150 mm scfd line direct construction cost would be in the vicinity of 47.0 million dollars. Operation and maintenance is anticipated to be 1.1 million dollars per year.

TABLE VIII. PROPOSED GAS PIPELINES

Physical Description and Capital Costs

Input Point	Pipeline Length Miles	Pipeline Size Inches O.D.	Compression Horsepower	Throughput Quantity MMCFD	Est. 1976 Construction Cost, Dollars	*Yearly Princi-ple Capital Charges	Operation & Maint. Dollars	Total/ Year	Cost/ MMBTU
Glasgow	275	16	1080	83	28,200,000	2,625,950	385.000	3,010,950	.11
Glasgow	275	20	1800	150	35,550,000	3,310,450	510,000	3,820,450	.07
Poplar	350	16	2475	83	36,600,000	3,408,250	685,000	4,093,250	.15
Poplar	350	20	4800	150	46,870,000	4,364,650	1,065,000	5,429,650	.11
New Town McCone County	350	16	3300	83	37,250,000	3,468,850	820,000	4,288,850	.16
New Town McCone County	350	20	4800	150	46,970,000	4,373,900	1,115,000	5,488,900	.11

* 7% Interest
20 Year Amortization Period

5. Results

Of the three potential sites considered, Glasgow Air Force Base is the preferred location in terms of projected direct gas transmission cost.

Gas transmission costs range from seven cents per million Btu (thousand cubic feet) at Glasgow Air Force Base for the 150 mm scfd facility to sixteen cents per million Btu at the New Town site in McCone County for the 83 mm scfd sized plant. The poplar site is the median example although it is closely associated with gas transmission costs at New Town in McCone County.

VII. INFRASTRUCTURE REQUIREMENTS[26]

The following section of this report deals exclusively with an anticipated human influx associated with the construction and operation of a coal gasification facility. Developing a coal conversion plant would require significant numbers of construction and operation personnel with a resulting impact on existing communities.

The three potential sites of Glasgow Air Force Base, Poplar, and New Town-McCone County are rural communities where a relatively large surplus of unemployed or skilled labor force currently does not exist. Therefore, this section does not take into account the existing work force nor attempt to determine what percentage of the employment requirement can be derived from the local area. Rather, it is assumed that all persons associated with the development will be acquired in areas remote from the site. This approach maximizes the human impact upon the environment--requiring more infrastructural development.

A. Potential Sociological and Economic Impact at Three Sites

This report quantifies and estimates the impact labor increases associated with gasification development at the above three potential sites. Existing community services and support systems have been identified in a comprehensive inventory (Appendices C-E). The reports explain where expansion of the existing infrastructure would be required to meet community standards established by various organizations.

Following the community inventories, a statistical comparison is drawn to minimize socioeconomic impact in the various communities. The base case for these comparisons is the labor force associated with an 83 mm scfd "Hygas" gasification plant. In the comparative impact section, the three communities are analyzed to determine where the least sociological and economic impact would be experienced. It is the designed purpose of this report to identify a site that would be least affected by the work forces associated with the gasification project.

A large industrial facility usually incurs an average construction period of approximately four years. Peak construction activity occurs during the third year when the work force reaches its maximum and places the greatest amount of stress on the environment. During peak construction, personnel would be consigned to semi-permanent housing developments such as trailer courts so that residential and community expansion does not overcompensate for the permanent population influx.

There are three size ranges and two technologies--each displaying its own labor requirements. These sizes and technologies include an 83 mm scfd Hygas, 180 mm scfd Lurgi, 180 mm scfd Lurgi, 250 mm scfd Hygas, and a 250 mm scfd Lurgi.

It should be mentioned that community support requirements for a given population has, to our knowledge, never been used to determine infrastructure requirements for planning purposes. If a community were designed and developed to this set of criteria, a well-planned and integrated community

capable of providing all services and amenities to the population in an ideal fashion would result.

B. Methodology

Before determining the impact of a coal gasification plant, it is imperative that three activities take place. First, the precise conversion process size and technology must be defined. Different size plants and/or technologies prove to have varied construction and operation employment profiles. Consequently, they produce different population impacts (see Models--Section C). Second, accurate employment figures and timelines must be utilized to project impact. These figures vary substantially from source to source; therefore, current and consistent engineering data was used for this report. Third, the alternative sites must be chosen and a community inventory compiled.

Basically, this was the procedure we followed. When these informational inputs were integrated, an analysis was completed on each community. These were evaluated with impact projections to determine additional requirements. Also, a comparison was drawn between each community and its respective infrastructure surpluses and deficiencies.

Indirectly, this methodology was applied to an 83 mm scfd "Hygas" gasification plant. Later in the report, the methodology is applied to larger scale (180 and 250 mm scfd) plants of both the Hygas and the Lurgi technologies in each potential community.

By measuring the quantified statistical impacts, we can determine the community that will experience the minimum socioeconomic impact as a result of siting a synthetic natural gas plant.

The following detailed procedure outlines the method used in preparing the statistical reports:

1. Gasification Plant

   Knowns: Plant Technology
   Plant Production Capacity

   Employment - must have:

   1. Total man years for construction
   2. Peak construction employment
   3. Number of years required for construction
   4. Operation employment

2. Construction Phase - Using the above, the figures for direct employment are spread over the number of years for construction.

   Indirect employment - This figure is achieved by multiplying the direct employment times a factor of 1.46.[35] Indirect employment levels evenly between the second and third years.

3. Operational Phase - During the final year of construction, staffing begins for the operation of the production plant. Twenty-two percent of the operational work force will be hired during this year.

   Indirect employment - This figure is achieved by multiplying the direct employment times a factor of 1.7.[35] The reason attributed to the increased multiplier is the permanent nature of operational work force.

4. Population Impact - In the construction phase, the direct employment is factored by 25 percent, leaving the remaining to be multiplied by 3.4. This figure (3.4) represents the average family size.[36] That total is added to the 25 percent (singles) for the total construction direct population. The construction phase (indirect) is factored by 10 percent and calculated the same as direct. The figure for the operations population is calculated the same way with the 10 percent factor to get total population figures.

Example: 100 direct construction employment

.25 x 100 = 25

Then 100
-25
75

Then 75 x 3.4 = 255

Then 255
+25
280 Total population - direct construction

146 indirect construction employment

.10 x 146 - 14 singles

Then 146
-14
132

Then 132 x 3.4 = 449

Then 449
+14
463 Total population - indirect construction

Then 280
+463
743 Total construction population

From these total population figures by phase, the number and age of the children is derived as follows:

Total construction (direct and indirect) population x .38 = the population from 1 year to 17 years old.[36] To get the age categories as shown, the following is used from the same source.

Under 5 years = Population from 1 to 17 total x .372

5 - 11 years = Population from 1 to 17 total x .378

12 - 14 years = Population from 1 to 17 total x .128

15 - 17 years = Population from 1 to 17 total x .122

The same formula is used for Operations.

It is necessary to know the existing population and the existing capacity of each service or facility to be compared for each survey site. These would include the existing water supply, sewage disposal, police protection, fire protection, school capacity, medical services, hospital services, nursing care, and housing.

Standards used to set these service impact quantities are derived from the "Community Planning Impact Standards" (Montana Trade Commission, August, 1976). An example of the method used in quantifying the impacts as cited in the comparative tables are exemplified by the following figures. Police and fire protection, schools, housing, and other parameters were analyzed in a similar manner.

Water Supply - 122 gallon/day/person
Population 1,000

Required residential water =
122 gallon/day/person x 1,000 residents

122,000 gpd = total residential water req.

Existing Capacity 100,000 gpd

$$\begin{array}{r} 122{,}000 \\ -\underline{100{,}000} \\ 22{,}000 \end{array} \text{ deficit}$$

Sewage Disposal - 1 lagoon surface acre/100 residents
Population 1,000

Required surface acres = 1,000 ÷ 100
Required surface acres = 10 surface acres

Existing Capacity 25 surface acre lagoon

$$\begin{array}{rl} 25 & \text{Capacity} \\ -\underline{10} & \text{Requirement} \\ 15 & \text{Acres surplus} \end{array}$$

C. Model Profile

The base case from a community impact determination is an 83 mm scfd "Hygas" coal gasification plant requiring approximately 4,600 man years for construction over a four-year period. During the first year of construction, the impact population figure will show a projected work force of 287 persons. This figure (added to the indirect associated employment and multiplied by the family size factor) will bring the first year up to a total population of 2,720 persons. Peak employment during the construction phase is required during the third year with a total of 2,300 construction workers projected. When extended for total population purposes, that figure will show 11,169 new residents to the applied location.

Beginning in the fourth year, a skeletal operational work force is hired; while by the fifth year, a total operational work force has been acquired with construction completed. During operations, a work force of approximately 600 individuals maintains, manages, and administers the facility. Extrapolating this figure shows a permanent residence of 5,800 total population.

The indirect, associated employment accounts for retail, wholesale, trade, clerical, and all other support requirements and amenities necessary for the work force during construction. The following statistical descriptions (Tables IX and X) show precisely how the gasification plant and the mine operation will operate from an employment definition. The model outlined above will quantify the significance of the projected impact to each of the three communities.

D. Summary Conclusions

The purpose of the preceding statistical analysis was to quantify the difference between existing and projected service requirements in potential site areas. This will permit an accurate assessment of the significance that siting an 83 mm scfd "Hygas" gasification plant would have on each community.

Important factors to keep in mind when reviewing this information are historical population changes, existing economic base, selected social service and facility availability, and new versus expanded capital expenditures required to meet the projected impact.

TABLE IX

GASIFICATION PLANT - POPULATION

Project Name: "Model"

Size & Tech.: 83×10^6 scf/day Hygas

Construction:	4600	Man Years	4 Years
Operations:	600	Man Years	30 Years

With Mine	Construction Phase		Direct		Indirect (1.46x)	
2,720	2,127	Year 1	287	803	419	1324
9,135	8,542	Year 2	1152	3226	1682	5316
11,169	10,576	Year 3	2300	5440	1682	
8,102	7,509	Year 4	861	2411	1257	3971

Total Man Years: 4600

	Operational Phase		Direct		Indirect (1.7x)	
		Year 4	132	418	224	709
5,801	5,119	Year 5	600	1896	1020	3223

Total Man Years: 600

Population Impact 3.4 Persons/Worker

Construction

Direct	5,440	(High Third Year)
Indirect	5,316	(High Third Year)
	10,756	

Operations

Direct	1,896
Indirect	3,223
	5,119

School-Age Children Impact

Construction	- Under 5 Years	1520
	5 - 11 Years	1545
	12 - 14 Years	523
	15 - 17 Years	428
		2566
Operations	- Under 5 Years	723
	5 - 11 Years	735
	12 - 14 Years	249
	15 - 17 Years	237
		1221

TABLE X

COAL MINING SITE - POPULATION MODEL

Project Name: "Model"

Size: 83 x 10^6 Hygas 4.5 Million Tons/Year

Construction Phase:	Direct Mining Employment	80	
	Indirect Mining Employment	117	
Operational Phase:	Direct Mining Employment	80	
	Indirect Mining Employment	136	
Population Impact:	3.4/Each Worker		
Construction	Direct	224	16,644
	Indirect	369	
		593	
Operations	Direct	253	
	Indirect	429	5,801
		682	

School-Age Children Impact

Construction -	Under 5 Years	84
	5 - 11 Years	85
	12 - 14 Years	29
	15 - 17 Years	27
		141
Operations -	Under 5 Years	96
	5 - 11 Years	98
	12 - 14 Years	33
	15 - 17 Years	32
		163

The data gathered on each community reflects, to varying degrees, the area's present capacity to easily accommodate the siting of such a plant. At the beginning of each site's infrastructure data, the significance of that community's projected impact is defined.

Tables XI and XII reiterate the existing community infrastructures of each reviewed community and gives a compilation of how these inventories accept or reject the projected impacts.

If sites are evaluated with criteria of achieving a positive sociological and economic impact, the statistical analyses indicate that Glasgow Air Force Base is the optimum choice.

Glasgow Air Force Base is selected primarily because of the large surplus of existing and unused facilities. A major influx of people necessarily and absolutely requires certain community facilities. Of these, adequate housing is most important. Glasgow, with nearly 1,000 surplus living units presently available, meets this critical need without delays for construction. Along with this housing need goes the associated utilities of sewer, water, streets, and energy distribution systems required to service these living units. Glasgow Air Force Base possesses these services in sufficient quantities to accept this projected impact with relatively little change. Another immediate need is for classroom space for the children of site personnel. Glasgow has a current surplus of 1,850 in school seating capacity. Medical care is another

TABLE XI

POST CONSTRUCTION FACILITY REQUIREMENT

Location	Water Supply	Sewage Disposal	Police Protection	Fire Protection	Hospital	Nursing Home	Medical Service	School	Housing
	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit
Valley County	X /	/ X	X /	X /	X /	/ X	X /	X /	/ X
Roosevelt County	/ X	/ X	/ X	/ X	X /	X /	X /	/ X	/ X
McCone County	/ X	/ X	/ X	/ X	/ X	/ X	/ X	/ X	/ X

. Surplus Deficit

Totals

Valley County	6	3
Roosevelt County	3	6
McCone County	0	9

TABLE XII

POST CONSTRUCTION SERVICE REQUIREMENTS

	Water Supply	Sewage Disposal	Polic Protection	Fire Protection	Hospital	Nursing Home	Medical Service	Schools	Housing
Location	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit	Surplus/ Deficit
Valley County	X /	/ X	X /	X /	X /	/ X	X /	X /	/ X
Roosevelt County	/ X	/ X	/ X	/ X	/ X	X /	X /	/ X	/ X
McCone County	/ X	/ X	/ X	/ X	/ X	/ X	/ X	/ X	/ X

Surplus Deficit

Totals

Valley County	6	3
Roosevelt County	2	7
McCone County	0	9

This chart adds operational population and impacts that total against existing infrastructure.

critical need that Glasgow Air Force Base has the capacity to handle immediately.

A secondary but significant factor indicating that Valley County would experience minimum sociological impact is the fact that the county has experienced similar growth patterns in the past. The community was able to adjust culturally, commercially, and socially to this increase in numbers with positive local attitudes. Glasgow is one of few cities in Montana experiencing boom and bust economic cycles in the 20th Century.

Of the three sites reviewed, only Glasgow Air Force Base possesses the immediate community infrastructure capable of handling the proposed coal conversion plant.

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APPENDIX

APPENDIX A

LAND CLASSIFICATION FOR POTENTIAL IRRIGATION PLANNING

Water Resources Division
of the Montana
Department of Natural Resources and Conservation

INTRODUCTION

The major features that determine the desirability of an area for irrigation development are the type of soil, topography, availability and quality of irrigation water, and the climate and markets. Soils and topography, together with frost free season and mean temperature largely determine the ability of an area to produce, assuming that a dependable water supply is available, and finally a market is necessary to obtain a profit from crops that are produced. This land classification is based on a long range projection which disregards the present available water supply for irrigation and market factors of crops produced.

Land classification is the process by which soils, relief and climate are systematically appraised and lands are placed in categories based on similarity of characteristics. Land classification surveys made by the Water Resources Division of the Montana Department of Natural Resources and Conservation are specifically designed to establish the degree of suitability of land for sustained irrigation farming. The objective is to outline the land areas that have a potential for irrigated agriculture. Because technological advances in irrigation are taken into account, slope and surface topography become less important as rapid expansion of sprinkler irrigation takes place.

The land classification survey separates the land areas into (1) lands having potential for irrigation termed "irrigable" in contrast to (2) the inferior "non-irrigable" lands which are unsuited for present or future irrigation because of unfavorable characteristics. The term "irrigable land" as used in this reconnaissance classification, includes land with soils topography and drainage features that are suitable for irrigation by gravity or sprinkler methods.

Lands classed as "irrigable" have soil, topography and climate that will support sustained irrigated agriculture with proper water management, drainage and other necessary conservation practices.

Lands which are classified as "irrigable" are divided into classes on the basis of their relative suitability for irrigation farming. Class 1 represents irrigable land with potentially high productive value; class 2 represents land of intermediate value, and class 3 includes land of the lowest value that may be suitable for irrigation.

The intensity of this land classification is a general reconnaissance survey. <u>Any future project development should be based on a detailed study</u> to pinpoint the exact location and limits of the land best suited for irrigation.

March, 1969

RECONNAISSANCE LAND CLASSIFI[illegible] SPECIFI[illegible]
MISSOURI BASIN [illegible] MONTANA
STATE WATER [illegible]
MONTANA WATER RESOURCES BOARD - [illegible] CLASSIFICATION SECTION

Soil or Land Characteristics	Class 1* Only Slight Limitations	Class [illegible] Moder[illegible] Limitations	Class 3 Severe Limitation
Dominant texture of Root Zone	Fine sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to clay (sands with sufficient w.h.c. can be included.)
Depth to: Clean sand, gravel and cobble	40" minimum	20" minimum	10" minimum
(A) Hard rock, Sandstone or non-saline Shale	60" minimum	40" minimum	30" minimum
Textural Modifers			
(Vol.) of tillage layer: Gravel (<3") Cobble (3-10")	No problem in tillage <15%	Moderate problem in tillage 15 to 50% <3" <15% (3-10")	Severe problem in tillage >-50% <3" 15 to 50% 3-10"
(B) Stoniness of surface and tillage layer, stones generally greater than 12" in diameter.	No problem in tillage	Cultivation not impractical. Stones >12" diameter; occupy 0.01 to 0.1% of the surface, and 0.15 to 1.5 cubic yards per acre foot.	Cultivation impractical unless cleared. Stones >12" diameter; occupy 0.1 to 3% of the surface, and 1.5 to 50 cubic yards per acre foot.
(B) Rockiness (Small outcrops within Soil type)	No problem in tillage Less than 2% of bedrock exposed.	=2% of surface may have bedrock exposed	2 to 10% surface may have bedrock exposed

In areas where use has demonstrated suitability, more severe modifiers can be rated irrigable for special uses not requiring tillage.

Available water-holding capacity (to a maximum depth of 4 feet)	> 6"	> 4"	> 2"
Permeability	Moderately slow - .20 inches per hour to moderate - 2.00 inches per hour, may exceed 2 inches per hour if sufficient water holding capacity is maintained - by field observation of soil texture, structure, etc.	Slow - .06 inches per hour to moderately rapid - 2.00 to 6.30 inches per hour - by field observation of soil texture, structure, etc.	Very slow - less than .06 inches per hour only in thin layers. To rapid - greater than 6.30 inches per hour if upper 4 Feet ~~[illegible]~~ of soil has sufficient water holding capacity - by field observation of soil texture, structure, etc.
Salinity and/or Alkalinity	Electrical conductivity not to exceed 4 millimhos/cm. may be higher under good leaching and drainage conditions. But not to exceed 8 millimhos/cm in top 4 ft.	Electrical conductivity not to exceed 8 millimhos/cm; except under good leaching and drainage conditions. Most horizons will have less than 8 millimhos/cm.	Electrical conductivity not to exceed 8 millimhos/cm in top 2 feet. Lower horizons may be higher under good leaching and drainage conditions, but not to exceed 15 millimhos/cm.

Slight or moderate salinity or alkalinity may exclude soils from Classes 1 thru 3 if associated with either or both a slow permeable substrata, or saline shale. Exchangeable sodium greater than 3.0 milliequivalents per 100 grams and/or sodium adsorption ratio greater than 12 of soil for cation exchange capacities less than 25 milliequivalents per 100 grams - may exclude a soil from irrigable class if leaching is not practical.

[illegible]

		Topography	
Slope	0-4%	< 8%	15% (Sprinkler irrigation on slopes > 8%)
		Drainage	
(C) Water Table	Easily maintained below 5' depth during growing season.	Practical to maintain below 40" depth most of the time in growing season (requires drainage)	Can maintain below 20" most of the growing season.
Overflow	No over flow	Free of overflow in growing season	Overflow may be hazard to crops in some years (2 or 3 in 10)
		Climate	
	Growing season greater than 90 days.	Growing season greater than 90 days.	Growing season may be less than 90 days.

Footnotes:

*Any one deficiency below the limits of a class is cause for downgrading to next lower class. Two or more ~~such~~ such deficiencies may cause downgrading two classes if judgement indicates they are additive in effect. Combinations of less severe deficiencies will be evaluated on a judgement basis.

(A) Soils known to be underlain by saline shale at depths as shallow as 60 inches are excluded from Class 1 through 3.

(B) For detailed description see Soil Survey Manual U.S.D.A. pp 217 & 220.

(C) Applicable only if soils in Classes 1 through 3 are permeable enough to permit leaching of salts when drainage is provided.

APPENDIX B

Seasonal Consumptive Use of Crops
for Irrigation Climatic Area II
(Seasonal Totals)

Crop	Total Consumptive Use (inches)	Effective Rainfall (inches)	Net Irrigation Requirement (inches)
Alfalfa	26.98	6.63	19.35
Corn, silage	18.66	5.18	13.48
Small Grain	17.38	5.62	11.76
Grass	23.80	6.91	16.89

Crop Acreages in Valley Co., Montana*

Crop	Thousand Acres
Alfalfa	28,000
Corn	1,327
Grain	203,472
Grass Hay	29,000

*Source: 1970, Census of Agriculture

APPENDIX C

GLASGOW AIR FORCE BASE, MONTANA IMPACT ANALYSIS

Glasgow Air Force Base, located in the geographical center of Valley County, is the first case site to be analyzed.

As an existing community, Glasgow Air Force Base possesses the largest infrastructure of any community in Valley County. It is situated 17 miles north of Glasgow, which is the county seat and that county's major retail trade center.

Glasgow Air Force Base was constructed between 1956 and 1963 to meet the Department of Defense's requirement for a major domestic SAC base. It contains an infrastructure designed to accommodate a population of 8,000. The base is defined in three major activity areas of--housing, contonment and airdrome--with relatively new (less than 20 years old) facilities and utilities. In 1964, the Department of Defense chose to close Glasgow Air Force Base and by 1968, it was inactivated. Since that time, a concerted effort to promote industrial and educational utilization of the facilities has been marginally successful. At the present time, nearly 50 percent of the facilities remain unoccupied.

Population

Valley County has experienced significant population shifts historically. Initially, the construction of Fort Peck Reservoir created a 36 percent increase in population during the 1930's. Again, in the late 1950's and early 1960's,

Valley County was subjected to a population influx due to the construction and operations of Glasgow Air Force Base.

The peak construction work force associated with an 83 MMscfd is projected to account for 800 persons more than the 1960 population of Valley County. The facilities at Glasgow Air Force Base would provide, in most instances, required levels of infrastructural support. In 1985, if the proposed facility was sited in the vicinity of Glasgow Air Force Base, Valley County's population is projected to increase by 35 percent to 18,000 residents.

Impacted County Historical Population Profile

Valley County (GAFB)	1940	1950	1960	1975	1976 Present Population
	+36%	-26%	+50%	-23%	13,300

Projected Population

Glasgow Air Force Base's 1976 population was nearly 2,000 people. This figure represents approximately 6,000 fewer residents than the base infrastructure was designed to accommodate. By siting the model 83 MMscfd Hygas plant at Glasgow Air Force Base, a peak increase of nearly 10,600 new residents would be experienced. This third year peak would then be reduced to slightly over 7,000 residents in the fifth year. The total operational population will be less than the population that resided on the base during the late 1960's.

1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
1,995	4,122	10,537	12,571	9,504	7,114

Economy

Valley County, as exemplified by the continous residence of 11,000 people through the high and low population periods, has as the major economic activity, grain and cattle production. This single permanent economic base is responsible for the maintenance of Valley County's commercial well-being. Local residents commonly use cattle or wheat prices and sales as a representative indicator of future prosperity. Local car sales, new housing starts and retail business volume are all directly related to agricultural productivity and sale prices.

Major infusions of federal monies in the Fort Peck Dam Project and the Glasgow Air Force Base have created boom and bust cycles in the local economy. Economists generally maintain that diversified economies are relatively more stable than nondiversified economic systems. If Glasgow Air Force Base were selected as the site for a new coal conversion plant, the single-based economy would be expanded into a multiple-based economy.

Conclusion

Generally, Valley County and specifically, Glasgow Air Force Base, represents the optimum case for reduced sociological and economic impact. Of the nine criteria under facility requirements, Glasgow Air Force Base is deemed sufficient to meet the projected impact in six of the categories. Additionally,

Glasgow Air Force Base is adequate in service requirements in six out of nine (see summary conclusion). The existence of Glasgow Air Force Base, once a community of nearly 8,000 residents, would accept the volumes of employees required by the development without causing major sociological, economic or environmental disruptions.

Housing, an immediate requirement, is nearly adequate to cope with the projected requirement of 2,092 permanent living units during operations. Peak construction would require a significant quantity of new semi-permanent living units. Adequate space and utility connections are available to effectively cope with this transitory requirement.

Other critical and immediate needs of utilities, water, sewage, schools and medical facilities are projected as adequate to support the anticipated impact.

Glasgow Air Force Base, on the basis of minimum economic and sociological impact is the preferred, most desirable site for the coal gasification facility. It offers reduced capital cost, minimum further land use, minimizes environmental disruptions occurring from the program's development and construction, and will not substantially increase demands for services above present capacity. The existing infrastructure at Glasgow Air Force Base coupled with its proximity to Glasgow, a trade center, would, nearly without change, be capable of accommodating the projected impact.

Housing

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	587	1,212	3,099	3,697	2,815	2,092
Capacity	1,465	1,465	1,465	1,465	1,465	1,465
Deficit			1,634	2,232	1,350	627
Surplus	878	253				

The housing capacity can be increased by approximately 400 living units with no utility or site preparation, i.e., relocatable housing foundations.

Also, the deficit can be accommodated with a city of Glasgow surplus of approximately 150 units. New construction will be necessary but by the fifth year, the housing deficit would be reduced to less than 100 units.

Housing units of approximately 500 units will require activation cost of approximately $600/unit before ready for occupancy. Utilities and streets are in place for these as well as the 200 relocatable foundations. Relocatables can be lot purchased at approximately $15,000 each.

This impact would for the first time in nearly ten years, utilize some 900 living units that have remained vacant since the U.S. Air Force left. The surplus housing is modern and well maintained. The new relocatable housing development would require only two-thirds the normal new development cost because of the existing streets, foundations and utilities.

Deficits during peak construction would require significant new temporary quarters to be located at the base.

Water Supply

Number of Gallons/Day

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	250,000	502,884	1,285,514	1,533,662	1,159,488	867,908
Capacity	3,009,600					
Deficit						
Surplus	2,295,046	2,506,716	1,724,086	1,475,938	1,850,112	2,141,692

Glasgow Air Force Base was constructed for a capacity of nearly 8,000 residents as well as industrial water consumption. The water supply is more than adequate to meet the residential demands for water. At peak construction employment, if all construction workers resided on base, a total water surplus of over 1.4 million gallons per day would be available. No further expansion would be required to accommodate increased water demand. No impact would be noticed in this area of service.

Hospital Service

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	8	16	42	51	38	28
Capacity	52	52	52	52	52	52
Deficit						
Surplus	44	36	10	1	14	24

The facility, a 52-bed hospital, is presently not used but would be available with only minor life safety code updated requirements. The structure is one of the most modern in Northeastern MOntana that provides hospital services to adjacent

communities within the northeastern portion of the state. A minimal investment in equipment and renovation of approximately $30,000 would be needed to reopen the facility.

In addition to this excellent facility, the city of Glasgow is constructing a new hospital. These two hospitals would enhance Valley County ability to serve all of northeastern Montana as a regional medical center.

Police Protection

Number of Men

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	3	6	15	18	18	10
Capacity	26	26	26	26	26	26
Deficit						
Surplus	23	20	11	8	13	16

Due to military requirements, the manning and facility capacities that now exist will meet and exceed the needs projected and required. This surplus would provide more than adequate police protection during both the peak construction and the operational phases of this projection. If surplus acquisition is possible, the equipment such as patrol cars and radio communications would reduce considerably the start-up costs.

Nursing Services

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	4	8	21	26	19	14
Capacity	0	0	0	0	0	0
Deficit	4	8	21	26	19	14
Surplus						

No nursing long-term beds exist on the base. It is anticipated that the former Bachelor Officer's Quarters could be, with minor renovation, adapted to fill this need. A Nursing Home in Glasgow along with the GAFB hospital surplus beds and renovation of other base facilities will be able to handle this deficit without new construction.

It is anticipated that the required bed numbers will not be critically needed as soon as this projection reflects. The construction population will be, on an average, much younger than that of residents in an established community. After the operation of a projected gasification plant creates a permanent residency, the projected requirement will become more realistic.

Sewage Disposal

Number of Surface Acres - Lagoon

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	20	41	105	126	95	71
Capacity	62.9	63	63	63	63	63
Deficit			43	63	32	8
Surplus	42.9	22				

With new sanitation requirements and a larger projected population figure, the existing sewage treatment would require mechanical expansion to meet the required standards. By mechanization, the existing size of the lagoon system could handle both the peak and operational population figures. This process allows the most flexibility with the least capital expense. The collection system and inflow systems are adequate and in place.

Fire Protection

Number of Men

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	7.5	15	34	42	32	24
Capacity	24	24	24	24	24	24
Deficit			11	18	8	0
Surplus	16.5	9				

Again, because of military requirements, the existing staffing, equipment and facility requirements more than meet the impact requirements. Fire protection manning could be provided that would be sufficient in peak construction and by the fifth year, no additional men would be required. This fire department has received national recognition for its past record in fire prevention.

Medical Services

MD's	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Population	1,995	4,122	10,537	12,571	9,571	7,114
Requirement	1	2	6	8	6	4
Capacity	2	2	2	2	2	2
Deficit		0	4	6	4	2
Surplus	1					
DDS						
Requirement	1	2	5	7	5	3
Capacity	0	0	0	0	0	0
Deficit	1	2	5	7	5	3
Surplus						
Optometrists						
Requirement	.5	1	3	3	2	1
Capacity	0	0	0	0	0	0
Deficit	.5	1	3	3	2	1
Surplus						

Part of the deficit can be accommodated by Glasgow town with no new facilities projected to be required. Facilities for clinical practice exist in the present hospital facility. Ad additional requirement exists for medical personnel. By the fifth year, however, two MD's, three DDS's and one optometrist would be necessary. During the third year, medical personnel requirements are higher.

Recruitment of medical personnel has been described as very difficult. The reason is not deemed monetary but rather location amenities. This problem prevails through most of rural eastern Montana.

Schools

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
School Age Pop.	1,990	2,498	4,028	4,514	3,782	3,374
Seating Req.	1,990	2,498	4,028	4,514	3,782	3,374
Seating Cap.	3,840					
Deficit			188	674		
Surplus	1,850	1,342			58	466
Teacher Req.	77	96	155	174	145	130
Deficit			38	57	28	13

The Valley County school system has historically experienced greater numbers of student influx than is projected here. As a consequence, only temporary facilities will be required during peak construction with a surplus capacity being available during operations. A minimal additional investment would be necessary to provide additional quarters during the second and third year of construction. With the exception of the Glasgow Junior High building, all existing facilities are relatively new and service-

able. The Junior High building will soon (next three years) either be totally renovated or a new facility constructed.

APPENDIX D

POPLAR, MONTANA IMPACT ANALYSIS

Poplar, adjacent to the Missouri River in the northeastern part of Montana, is the tribal headquarters for the Fort Peck Indians, Assiniboine Sioux. This community developed over the years primarily through river and railroad trade, has as its major community activity the administration tribal business and services. As the second largest community in Roosevelt County and the tribal headquarters for the Fort Peck Indian tribe, Poplar provides many of the social services required by the county residents.

Unemployment on the reservation is high, averaging nearly 45 percent of the total work force. Local Development Corporations have taken the initiative to identify possible industrial development potential for the area. However, to date, economic development in the area has not been dynamically occurring.

Population

Roosevelt County has generally experienced a decrease in population in the last thirty-five years. Roosevelt County would realize a growth of 46 percent by 1985 if the gasification plant was sited in the vicinity of Poplar.

Impacted County Historical Population Profile

Roosevelt County (Poplar)	1940	1950	1960	1975	1976 Present Population
	-7.5%	-3%	+23%	-10%	10,000

Projected Population

Poplar's 1976 population is estimated to be approximately 1,400. Utilizing the 83 MMscfd Hygas scenario, a population increase of slightly more than eleven thousand would be experienced in the third year of facility development. In the fifth year, it is anticipated that the population will be again reduced to approximately the 7,000 level responding to a decreased demand for a work force.

1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
1,400	4,121	10,535	12,569	9,502	7,201

Economy

Roosevelt County has as the base economy, agriculture, tourism, and minor manufacturing. The constantly declining population and the high rate of unemployment are directly related to mechanizing agricultural production.

Poplar relies on the retail trade areas of Wolf Point, 22 miles west and Sidney, 70 miles to the southwest. Most social services required by Poplar are readily available because of the presence of the reservation headquarters.

The siting of a coal conversion plant at Poplar would have a dynamic effect on a lagging economy. It would diversify the economic base and additionally, would cause an unemployment decrease.

Conclusion

The Roosevelt County site is deficient in six facility requirements and seven service areas (see summary conclusion).

Major expansion of the present infrastructure would be necessary to accommodate the projected levels of growth. In the operations phase, over 1,600 new housing units would be required. An additional high school and three elementary schools would be constructed. Expansion and new construction of sewer and water systems and further utility interconnections would be needed. Police and fire services would be expanded and would require further equipment purchases and capital outlays for new buildings.

Even with the obvious attributes of reducing unemploymnt and stabilizing the economic base, Poplar would experience a major socioeconomic impact by the siting of a conversion plant. An increase in population of nearly 50 percent in the county and better than 400 percent in the town are significant to cope with adequately.

Housing

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	411	1,211	3,098	3,696	2,795	2,118
Capacity	483					
Deficit		728	2,615	3,213	2,312	1,635
Surplus	72					

Housing capacity expansion would be the most significant cost item created by this impact. The construction peak would require vast mobile home capacity, almost double that of the required permanent housing during operations. This impact would cause additional requirements of subdivisions, streets, and utility services. The impact associated with the fifth

year development, which would necessitate the construction of over sixteen hundred living units would create significant stresses upon the existing community.

It must be pointed out that housing and its associated utilities are the most critical requirement and has the least lag time available for meeting the need.

Water Supply

Number of Gallons/Day

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	169,458	502,640	1,285,270	1,533,418	1,159,244	878,522
Capacity	432,000					
Deficit		70,640	853,270	1,101,418	727,244	446,522
Surplus	262,542					

With an approximate population expansion of nearly 415 percent between 1976 and the operational phase of this location, the water supply system would need to be expanded by at least three times the original capacity. Access to Missouri River water presents the obvious alternative for the expansion of this capacity. Storage treatment and distribution systems will require vast new construction capital expenditures.

Hospital Service

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	6	16	42	50	38	29
Capacity	22	22				
Deficit			20	28	16	7
Surplus	16	6				

Again, a near sufficiency of hospital facilities presently exist. Expansion will be required but a deficit of only seven hospital beds in the fifth year of development would indicate that this would be minimal. The dependency on this facility by the reservation population could cancel the near sufficiency during the operational phase. The third year peak construction could possibly be absorbed by the Wolf Point hospital, but the need for temporary additional facilities seems evident at that point.

Police Protection

Number of Men

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	2	6	15	17	13	10
Capacity	4					
Deficit		2	11	13	9	6
Surplus	2					

Poplar's personnel and facilities will require expansion by projected population impact. This would additionally require new physical construction adequate to provide the police with an expanded headquarters, patrol cars and other associated equipment. This new requirement could logically fit into the community construction plans for a city office complex along with the new expanded fire protection requirement.

Nursing Services

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	3	8	21	25	18	15
Capacity	21					
Deficit			0	4		
Surplus	18	13			3	6

This service should be sufficient to meet the anticipated growth in the community. It must be pointed out that the size of the existing service is primarily derived to accommodate the reservation population. If the existing facility is to continue that regional service, expansion of the facility will be necessary.

Sewage Disposal

Number of Surface Acres - Lagoon

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	14					
Capacity	560,000					
Deficit	Existing Health Hazard					
Surplus						

The sewage disposal system is presently deemed inadequate. Poplar is planning a new system to be active in 1977, projected to handle 6,000 persons. The new system will be inadequate to handle the projected conversion plant and ancillary residents numbering 11,000 during peak construction. This would require an extensive capital expenditure for not only the treatment facility but also by virtue of the projected 1,635 new permanent residences, new collection systems would be required.

Fire Protection

Number of Men

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	5	14	35	42	32	24
Capacity	28 Voluntary = 7 FTE					
Deficit		7	28	35	25	17
Surplus	2					

New facilities, men and equipment will all be required by Poplar. Presently, Poplar has a voluntary fire department manned by local citizens. Due to the dimensions of the projected population, a full-time and expanded fire department would be required. Further investments in equipment and facilities would be necessary. Again, this could be incorporated in a new city office complex.

Medical Services

MD's	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	1	2	6	7	5	4
Capacity	4					
Deficit			2	3	1	0
Surplus	3	2				
DDS						
Requirement	1	2	6	6	5	4
Capacity	1					
Deficit	0	1	5	5	4	3
Surplus						
Optometrists						
Requirement	.5	1	3	3	2	2
Capacity	2					
Deficit			1	1	0	0
Surplus	1	1				

The existing medical services are nearly adequate in numbers because of the Indian Reservation Headquarters being located at Poplar. Most likely the need for private practitioners would exist and new facilities would be required. This area has had a difficult time recruiting medical professionals and that could cause a significant problem in meeting this need.

Schools

Seating Capacity

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
School Age Pop.	1,976	1,517	2,048	3,534	2,701	2,252
Seating Cap.	1,060					
Deficit		457	988	2,474	1,641	1,192
Surplus	192					
Teacher Req.		58	79	136	103	87
Teacher Cap.						
Deficit						
Surplus						

Poplar, with its historical declining population, has a present surplus of seating capacity. Even with this surplus, they would fall 265 seats short of the first year's requirement.

With the projected population statistics, the requirement for an additional 1,200 permanent seating capacity would require doubling the size of the high school and most likely, three more elementary schools. The temporary classroom alternative would be projected to meet the needs during peak construction.

Time is critical in bringing the schools up to the capacity required by this projected population expansion.

APPENDIX E

NEW TOWN, McCONE COUNTY-MONTANA IMPACT ANALYSIS

Circle, with a population of 964 residents, is the only existing incorporated community in McCone County. This represents nearly 50 percent of the county's total population. Circle is both the county seat and the county's retail trade center.

New Town would be located to the Northwest of Circle between two strippable lignite deposits, the Redwater and the Circle West seams. This is a conceptual, hypothetical community that does not presently exist and which could be developed to provide amenities to individuals employed at a strip mine or coal conversion facilities in the coal region. It would be in many ways similar to a traditional "boom" or "company" town. This is a model of a planned community dedicated to support personnel employed in the coal production, utilization industry. It is not a proposed community; it is utilized for determining land utilization and the approximate cost of developing a dedicated residential community to support employees of a coal gasification facility.

Population

The population of McCone County has decreased over the past 30 years much like the rest of Northeastern Montana which is traditionally agriculturally based. The mechanization of agriculture, even with increased acreage under cultivation, has resulted in fewer job opportunities for the region.

McCone County Historical Population Profile

McCone County	1940	1950	1960	1975	1976 Present Population
	-21%	-13.5%	+3%	-15%	2,720

Projected Population

New Town's growth rate would parallel the 83MMscfd model population. During the third year of construction, peak population growth would be experienced at the eleven thousand level. By the fifth year, during facility operations, the population of New Town would stabilize at approximately six thousand.

1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
0	2,720	9,135	11,169	8,102	5,801

Economy

Agricultural related employment represents nearly fifty percent of McCone County's existing economic base. In 1970, the employment of nearly 46 percent of the eligible work force was directly in farm management and labor.

The McCone County site would be a grass roots development. It could be planned and constructed to accommodate employees of all coal related industries in the local area. It is estimated, however, that such a development would cost in the vicinity of 96 million dollars and would utilize over 2,400 acres of land. Associated with this, the construction of roads and an airport would require additional acreage.

New Town would theoretically be serviced by Circle, Glasgow, Wolf Point and Glendive. Billings would be the closest wholesale distribution and trade center, approximately 240 miles to the southwest.

Conclusion

McCone County would be effected sociologically and economically to the greatest extent by gasification development. With a relatively small, rural population of 2,700, the influx of 4,600 related with the development would cause the County population to increase in a five-year period by 170 percent to the 7,300 level.

If New Town was proposed, the construction of roads, highways, an airport, housing, small businesses, parks, fire and police protection, and other local government services would be required. This would result in the direct utilization of over 2,400 acres of land and a capital expenditure of 96 million dollars. The cost of these developments would, to a degree, be the responsibility of coal related industry. However, a share of the cost would be borne by both the state and local government through the coal severence tax impact relief fund and local taxes.

McCone County, if a plant were to be sited there, would experience the most significant socioeconomic impact and is presently the least prepared to accommodate dramatic growth.

Housing

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		800	2,686	3,285	2,383	1,706
Capacity	0					

NEW TOWN


49°
107°
105°
D A N I E L S
S H E
V A L L E Y
R O O S E V E
Glasgow
Wolf Point
FORT PECK RESERVOIR
M C C O N E
C H
F I E L D
D A W S O N
P R A I R I E
5
E-4

With 3,109 family units maximum being directly and indirectly associated with the energy facility, it is projected that 2,500 living units will be required in the new town. Using ratio figures for the area, the following will be true:

60 percent dwellings will be owner occupied
40 percent dwellings will be renter occupied

It is anticipated that semi-permanent housing such as mobile homes will comprise the majority of units during the construction phase. As the development nears operation, the building of new private homes will increase.

Allowing for single and multiple dwelling construction for the entire community, costs would average $24.30/square foot* for an average of 1,150 square feet/family. This would cost approximately $69,862,500 for housing units associated with the development.

Water Supply

Number of Gallons/Day

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		331,840	1,114,470	1,362,618	988,444	707,722
Capacity	0					

A source for the community water supply would have to be identified. Wells could perhaps provide a percentage of this requirement. However, water could be acquired from the Missouri River, approximately thirty-five miles to the north which would necessitate the construction of a pipeline at an approximate cost of one to two million dollars. A plant for the treatment

of the water would cost in the vicinity of one million dollars. A system to store and distribute the community water supply would cost 3.9 million dollars.

Hospital Service

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		10	36	45	32	23
Capacity	0					

During the third year of construction, a hospital with a capacity of approximately fifty beds would be needed. By the operations phase, this requirement decreases to twenty-three, resulting in a required hospital capability of approximately thirty beds. A thirty-bed hospital could be constructed for 500,000 to 750,000 dollars. This would provide adequate capacity to service the anticipated population.

Police Protection

Number of Men

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		4	13	16	11	8
Capacity	0					

The number of police personnel necessary to insure the public security of the community would be approximately fifteen during operations and construction. An average salary of $650 per month would be expended totalling over $110,000 per year for personnel. Equipment and facilities necessary to support the police force would require an additional capital expenditure of $1,600,000.

Nursing Services

Number of Beds

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		5	18	22	16	12
Capacity	0					

A nursing home capable of supporting twenty-five long-term patients would be constructed at New Town. Seven thousand two hundred square feet of space would be necessary at an approximate cost of fifty dollars per square foot. Such a facility is estimated to cost in the vicinity of $360,000 and would be capable of supporting the anticipated number of nursing care patients associated with the development.

Sewage Disposal

Number of Surface Acres - Lagoon

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		27	91	112	81	58
Capacity	0					

To dispose of wastes associated with the community, a sewage system would be constructed. The total cost of developing such a system would be approximately 3.3 million dollars. This would entail a waste collection system at 1.4 million, a treatment facility costing 1.7 million, outflow lines at $74,000, and solid waste handling, requiring a capital expenditure of $158,000. The lagoon associated with the treatment facility would demand almost 55 acres for aeration and settling.

Fire Protection

	Number of Men					
	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement		9	30	38	27	19
Capacity	0					

To insure adequate fire protection, eight fire companies should be established. Each company would be composed of five individuals plus a fire chief. Annual personnel costs would be approximately $366,000. Facilities to support this service would require an additional capital expenditure of $528,600.

Medical Services

MD's	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
Requirement	0	2	5	7	5	3
Capacity	0					
DDS						
Requirement	0	1	5	6	4	2
Capacity	0					
Optometrists						
Requirement	0	1	2	2	2	2
Capacity						

To insure adequate medical care, MD's, dentists and optometrists would be attracted to the community. Acquisition of these professionals could be difficult with doctors not necessarily being attracted to a remote location such as New Town. However, to achieve a level of sufficiency in this criteria, three general practitioners, two dentists, and two optometrists would be necessary.

Schools

	1976	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
School Age Pop.	0	649	2,038	2,523	1,792	1,222
Teacher Req.		25	78	97	68	47

To attain sufficiency in the New Town school system, two elementary schools, one junior high school and one high school would be constructed. Each elementary would be designed to support four hundred students and cost approximately $650,000 per school. The junior high would support 300 students and requires $800,000 investment.. A high school, also with a capacity for accommodating 300 students, would require an additional $800,000 expenditure. To construct the capital facilities necessary to support the anticipated school-age population would require an approximate expenditure of three million dollars.